METALLURGIA

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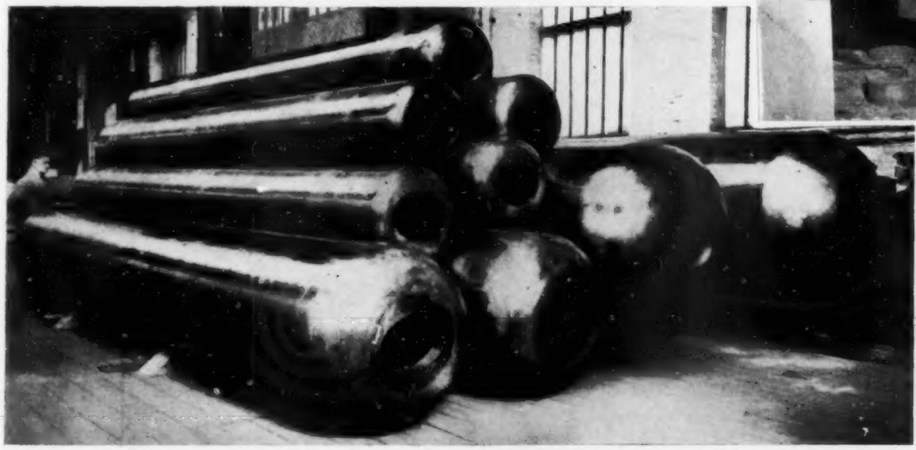
Forged Pressure-Drums for Boilers

The manufacture of hollow forged steel pressure vessels for high-pressure boilers has become highly specialised because of the difficulty experienced in producing large hollow forgings possessing uniformly high physical properties without defects or flaws, and the new conditions of service resulting from higher pressures. Many of these vessels have been made in Sheffield, and further orders received include boiler drums for the new power station at Fulham.

A 175-ton ingot as lifted from the mould.



A consignment of high-pressure boiler drums for the 47,000-ton ship, "Conte di Savoia."

EACH succeeding year has seen an increasing demand in new directions for hollow forged steel pressure vessels for high-pressure boilers, compressed-air chambers, chemical works, oil-cracking plant, etc., until their manufacture has become highly specialised. This specialisation is due partly to the technical difficulty of producing large hollow forgings possessing uniformly high physical properties without defects or flaws, and partly because new conditions of service involving high working temperatures and pressures, and the attack of various gases, have made necessary very thorough investigation of the properties of the materials which can be most suitably employed for this class of work. In particular, the phenomenon of "creep" which lies at the root of the successful performance of vessels subjected to internal pressure at high temperatures necessarily demands a close study and investigation with specially devised apparatus, a branch of investigation in which the English Steel Corporation were early pioneers.

For over half a century Vickers, Armstrong Whitworth and Cammell Laird have been recognised as the greatest manufacturers of guns—which are essentially high-pressure vessels. The English Steel Corporation, in which the steel interests of these firms are incorporated, has added to this unique experience a close study of the manufacture of high-pressure vessels for many peaceful purposes, until at this date it is looked upon as the authority for this class of work.

Important work of this nature regularly passes through these works, recent examples of which include the whole of the boiler drums for the Babcock and Wilcox boilers installed in the *Queen of Bermuda*, built by Messrs. Vickers, Armstrong, Ltd., launched at Barrow on September 1 last. These drums were each made from a single piece of steel, including the closed ends, as were the high-pressure boiler drums for the 47,000 tons T.S.S. *Conte di Savoia*, built by Cantieri Riuniti dell' Adriatico. The largest of these drums has an inside diameter of 54 in.; the group illustrated shows one consignment of these drums before leaving the Vickers' Works at Sheffield.

Another type of high-pressure vessel was produced in the form of catalyser columns for the ammonia-recovery plant for the Consolidated Mining and Smelting Co., of Canada, in the manufacture of which it was necessary to use ingots weighing 100 tons, the finished weight of the heaviest catalyser column being $40\frac{1}{2}$ tons. In these vessels pressure of 2 tons per sq. in. at high temperatures are encountered.

More than one of the foreign navies carries boiler drums made by the English Steel Corporation, and an order for water drums for water-tube boilers to be used by a foreign navy has just been completed at the Sheffield Works.

The closed-end type of boiler drum has been adopted by the designers of the new super-power stations, as being the most suited to withstand the high pressures and temperatures used, and it is of interest to note that the whole of the forged boiler drums for the six Stirling boilers to be installed in the new power-station at Fulham will be manufactured by the English Steel Corporation at their Vickers Works. The largest of these drums will be approximately 40 ft. long by 5 ft. 3 in. outside diameter, and they will be made in one piece, including the closed ends, which are formed from the tubular forgings by a process specially developed by this firm. The ingot required for one of these drums will weigh 175 tons. An ingot of this size, which is claimed to be the largest ever made in Sheffield and in this country, is shown in the accompanying illustration, just lifted from its mould by a 200-ton crane.

In producing hollow forgings, the usual practice is to anneal the ingot immediately after stripping it from its mould (whilst still hot), afterwards cooling it slowly in the furnace, the object being to allow a hole to be made through the centre by trepanning, after the top and bottom ends have been cut off. Cooling such a large ingot, however, may occupy three or four weeks, and in order to save time, as well as to obviate the possibility of stresses caused by cooling, the English Steel Corporation has developed a process of "hot piercing" or punching, whereby a hole is made through the ingot without cooling it. The hollow billet thus prepared is forged by the usual processes of expanding under a powerful hydraulic press. At one stage during the forging the mass of metal will be expanded to 103 in. in diameter. When the "hot-piercing" process is employed the completed forging is made from metal which has never been allowed to cool below a red heat, after casting, until it has been annealed as a finished forging.

Pneumatic Dust Removal Plant.

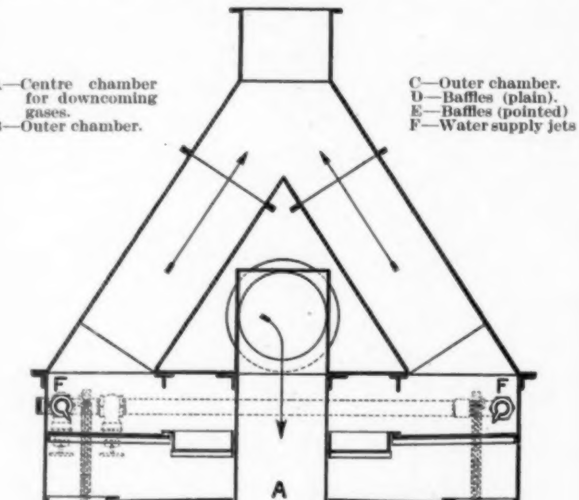
FOR dealing with the troublesome problems of soot and dust deposits in combustion gases, as well as riddlings in mechanical stoker practice for steam boilers, the pneumatic method possesses many advantages, providing that it is installed on right lines. This applies also to many other sections of large-scale dust removal in iron and steel and general metallurgical establishments, as well as coke-oven plant and coal mines. A notable example of this method is an equipment by Messrs. Davidson and Co., Ltd., Belfast, now operating with great success at the Deptford West Station of the London Power Co., Ltd., running with chain-grate stokers burning a blend of coal and coke.

Originally this installation at Deptford West consisted of riddlings and soot-extraction plant for six "Babcock and Wilcox" boilers and riddlings extraction plant for six "Stirling" boilers. Subsequently, however, because of the efficient results obtained, there was an extension in the shape of riddlings extraction plant for two additional "Thompson" boilers and a complete vacuum-cleaning equipment for the whole boiler-house, comprising a total of 14 boilers, which will eventually be extended to 18 boilers.

For this purpose motor-driven exhausters are used, along with rotary separators and complete air-washing equipment, the riddlings, for example, being conveyed horizontally for 170 ft., lifted vertically 117 ft., and then carried horizontally again for 50 ft. to one of four receivers, each of 300 cub. ft. capacity, fixed over the coal bunkers. The whole arrangement of piping is of the most complete character, with control valves, so that the riddlings from any part of the boiler-house may be deposited in any receiver and passed down to the equivalent boiler below to be burnt along with the coal.

As regards soot and deposited dust collection, this is carried out in the lower baffle of the boilers by means of extraction pipes, and also in the economisers by means of a series of small hoppers provided with a complete arrangement of collection pipes at the base, the soot being finally collected in one of the two very large receivers, each of 500 cub. ft. capacity, which may be emptied by means of trucks or into the ash-sluice circuits.

The separator used in this connection for dealing with the air, after it leaves the receivers, consists essentially of two perforated discs driven at high speed by a motor, and on each of these discs is mounted a number of inclined plates through which the air flows, the action being to throw out the solid impurities by means of centrifugal force.



Section through air washer.

The air is cleaned by passing it through water in a specia washing unit, consisting of a closed mild steel tank, partly filled with water, and containing a series of baffle-plates, the air entering at one end, bubbling through the water, and passing over the baffles, with final discharge in a cleaned condition, extremely intimate contact with the water being obtained with the removal of the finest particles. As regards the exhausters used, these are of an efficient reciprocating type, and can easily give a vacuum of over 24 in. mercury, although the figure actually required in practice for a very large installation is only about 6–12 in. mercury.

We have received a booklet which contains information and the results obtained from a careful research on the effects of adding molybdenum to cast iron for various compositions. As a result of these investigations, apparently where increased strengths and good machining properties are desired, the molybdenum-chrome and molybdenum-nickel irons offer splendid opportunities. Copies of this booklet may be obtained from High-speed Steel Alloys, Ltd., Ditton Road, Widnes, Lancashire.

Degreasing and Cleaning

(Vapour Cleaning)

By W. F. Jesson.

Old methods were contrasted with the latest practice, and attention directed to the use of trichlorethylene in both liquid and vapour phases as a degreasing agent, at a recent meeting of the Sheffield Section of the Institute of Metals, an extract of which is given.

DEGREASING is a term covering a wide range of requirements from cleaning dirty machinery up to producing chemically clean surfaces for critical finishing operations. It includes all forms of unsaponified grease and oil, and most of the compounds containing various waxes. Oil may be applied to reduce friction between moving parts, or to protect certain metals from rusting during fabrication, but very searching methods have to be introduced when it is required to remove oil completely from metal surfaces in order to subject them to finishing processes.

The use of clean dry sawdust—one method formerly used for this purpose—is now practically confined to the aluminium hollow-ware trade where the articles are large, light, and free from crevices in which the sawdust can lodge; while, except in a few special trades, such as the hollow-ware trade, burning off is obsolescent, though "sweating" to a temperature of 300° F. to 400° F. in gas-heated stoves persists here and there to dry out work for enamelling which has been previously washed in white spirit. This process served quite well on open surfaces, but it was not efficient where there were wired edges, turned edges, spun joints, etc.

Another method of degreasing is the boiling caustic-soda bath. This is quite ruled out where aluminium work is concerned. It is not a very pleasant process to handle, and in some cases it is very slow.

Proprietary alkaline cleaners can be excellent in saponifying animal and vegetable oils, but they can only deal indirectly with mineral oils. Of the chemical cleaners which act by dissolving oils and greases, petrol and benzine may be dismissed on the fire risk alone. Carbon tetrachloride is a good solvent in many respects, but against it is the fact that in the presence of moisture it will attack certain metals; it is positively dangerous to use it on aluminium and metals of the same class.

Of the chemical solvents, it will be found on examination that trichlorethylene has the following advantages :—

1. It removes all oils and greases, whether of animal, vegetable, or mineral origin, and dissolves them at the same rate. This does not include metallic soaps, which only very slowly dissolve in trichlorethylene; these soaps are only added to lubricants to meet certain special requirements. Trichlorethylene also dissolves waxes, tars, gums, rubber, and many resins.
2. It has no detrimental action on any metal, even when water is present.
3. It is free from any component which may be deposited on the metal.
4. It leaves the work dry, ready for any succeeding process.
5. It is non-inflammable, whether in vapour or liquor phase.
6. It is antiseptic. Ordinary draught-free ventilation is the only health requirement in factory use.
7. It operates at a low temperature (87° C.).
8. It can be reclaimed by distillation.

Trichlorethylene.

Trichlorethylene as made by the Imperial Chemical Industries, Ltd., is a commercially pure liquid specially stabilised to prevent decomposition when exposed to light and heat. It is a clear, colourless liquid, having a pleasant smell.

The liquid is nearly one and a half times heavier than water, Sp. Gr. 1·47, to be exact, at a normal room temperature of 60° F.

The hot vapour is about four and a half times heavier than air.

It has a low specific heat, and therefore is readily raised in temperature with a small expenditure of heat.

It has a low latent heat, and therefore is readily converted into vapour. In fact, 9¼ lb. of trichlorethylene can be vaporised by the same amount of heat as is required to convert 1 lb. of water into steam.

It has low surface tension, and therefore good wetting power: this, with high specific gravity, gives rapid penetration.

It is a volatile liquid, but can be easily stored under water if desired; there is no difficulty in effecting separation.

Cold solvent will evaporate until it has saturated the air above it. If this saturated air can be imprisoned by lids over the plant the loss of solvent will be checked. But if by draughts and lack of lids the air in the plant is constantly changed, then appreciable loss of solvent will occur. The rate of this loss would be increased if the solvent were warm, so when a plant is shut down at night it is most important to close the lids and retain the solvent-laden air.

In normal working conditions, where a layer of trichlorethylene vapour at boiling temperature is being held at a constant level by a condensing coil all round it, then some loss of solvent is proceeding through diffusion from the hot vapour surface into the air. The air just above the vapour becomes saturated with the solvent, and it is not possible to control this solvent in air by ordinary cooling methods.

It is the extent to which this saturated air can be controlled which determines the economy of its use in degreasing plant. If the vapour is maintained at the operating level in a plant, but no work is being degreased, a loss of solvent will take place through diffusion at the rate of about 0·046 lb. per sq. ft. of vapour surface per hour. This loss may be compared to an overhead charge; if the plant is worked to its full capacity this stand-by loss becomes negligible, but if the plant is only working at a fraction of its capacity then the stand-by loss becomes more perceptible.

From all available evidence on hand, trichlorethylene is not cumulative in its effects on the human system, and it produces no permanent impairment of health as a result of ordinary exposure to its vapours. Excessive exposure produces a narcotic effect—*i.e.*, the operator will feel sleepy at the time, and he may feel dizzy at first when he goes out into the open air. It is therefore desirable that he shall not have to lean over right down into the plant to pick out the cleaned work, for in so doing he will be breathing the strongly impregnated air, and this would affect some individuals more than others. On the other hand, the slight smell which may at times be noticed near old-type plants will not have any perceptible effect whatever on him.

Thus it may be said that from the health point of view the only care required with trichlorethylene plants is not to breathe continuously the strong vapour within the

plant, and to see that ordinary ventilation removes the smell of the burnt gases from gas-heated plants, as well as such slighter smell as may come out with work which is inclined to trap some solvent in hollow parts.

Plants.

Although the characteristics of trichlorethylene had long been known, it was not until 1927 that an attempt was made here to develop commercially the use of it to remove grease from metal parts. Degreasing plants were then made consisting of a tank with a lid : in the bottom of the tank was a cooling coil connected to a water supply, and a similar coil was attached to the lid. A few gallons of solvent was poured into the tank, and the greasy work to be cleaned was placed on a grid just above it. A flow of water was directed through the lid, condensing coil, and the solvent was then boiled by a gas burner fixed beneath the tank.

The vapour formed condensed to a liquid on the lower part of the work with which it first came into contact. The liquid dissolved the grease, which trickled back to the base, or sump, of the tank. Here the heat again vaporised the solvent, leaving the oil and grease in the sump owing to its higher boiling point. A large number of these plants were supplied and gave great satisfaction at the time as an improved degreasing process. Since then the method has been developed, and many modifications made in the design of plants.

A feature common to all I.C.I. degreasing plants is the distillation equipment. This consists of a trough attached beneath the top cooling coil, into which all the condensate drops and overflows back into the sump. By means of a tap this distillate can be run outside the plant into any convenient can. In condition this distillate is just as good as newly delivered solvent from the makers.

In steam-heated plants the steam pressure is usually kept down to a maximum gauge pressure of 30 lb. per sq. in. ; this gives a temperature of about 130° C., ensuring a good recovery without overheating. I.C.I. degreasing plants heated by gas, electricity, or oil are thermostatically controlled in order to prevent the trichlorethylene and oil mixture becoming overheated. Plants heated by steam are not thermostatically controlled, since they are designed only for steam pressures up to 30 lb. per sq. in. gauge, and saturated steam at this pressure does not provide a temperature sufficiently high to overheat the mixture.

The recovery of trichlorethylene depends upon circumstances, but it may be said that an average figure for recovery by distillation is from 85 to 95% of the solvent present in the sump.

Solvent Consumption.

Two factors influence the solvent consumption : The amount of solvent which may be trapped in the work in either the vapour or the liquor state, and the surface area of the work from which the solvent has to dry off.

Solvent trapped in wired edges and in pockets must be looked for in the first place, and the work must be lifted out of the vapour so it drains out freely. Trapped vapour is less obvious to the operator, and he must be properly instructed how to avoid dragging this out, or else a high solvent consumption will be recorded.

Loss of solvent through the above causes can be kept down with a little care, and it is the general experience that solvent consumption during the first month is higher than it is subsequently when correct working is understood and applied. The chief factor in solvent consumption is the drying off of solvent from surfaces. In fact, surface area is really the term in which solvent consumption should be measured.

If a sheet of metal is dipped into cold trichlorethylene and raised gently out of it, there will adhere to it a film of solvent the thickness of which is determined by the surface tension of trichlorethylene ; it is a liquid film of appreciable thickness. But if the same sheet is dipped into boiling solvent, when it is lifted out of it the sheet must pass through a layer of trichlorethylene vapour above the liquor ; it emerges from this carrying a much thinner film, owing to the relative viscosity between hot and cold trichlorethylene. This film readily dries off with far less loss than that produced by the thicker film.

The film which dries off is absorbed by the air in the plant. The air just above the solvent becomes saturated, and this belt of saturated air gradually increases in depth and checks diffusion from the surface of the boiling solvent. It is vital to the interests of economy that this saturated air should not be disturbed nor be carried out of the plant by draughts across the top of it.

Apart from loss of solvent being caused by draughts, it should be noted that draughts defeat the very purpose of the health recommendation that these plants should be placed in a well-ventilated position. Ventilation is to remove any trace of smell which might come from certain classes of work if they are removed too rapidly from the vapour, whereas draughts can produce a smell from the plant at all times.

When producing new types of plant, the fundamental point which the Designs Department has always before them is to allow the work to be raised steadily out of the vapour through a belt of still air, where it can dry off, and where the impregnated air can remain free from disturbance.

Many types of plants are produced by I.C.I., which may be classified as : Vapour, liquor, and a combination of the two phases, and each class is made in hand-operated form, and also in mechanical-conveyer form. Only experience can determine what is the right type of plant for any particular work.

Liquor plants have the advantage that they will remove solids as well as grease from work. But the liquor becomes charged with solids in suspension as well as grease in solution. Accordingly, a second and a third liquor compartment is arranged in line with the first. The work is then cleaned in the first dip, and leaves it with slight traces of oil stain and a few specks of solids still visible ; these are removed in the second dip. The third dip is provided for complete safety after a long run of work.

When the work to be degreased is larger than smallwares, the amount of liquor needed to charge the three compartments may be considerable. In this case the vapour process meets the need excellently, for 1 gal. of the liquor will provide over 50 cub. ft. of vapour. This physical property offers several advantages, for not only can large objects be degreased by the vapour from small amount of liquor, but also the plant can be heated to its operating temperature in a shorter time, and the cost of a charge is much less, as is the time and cost of distilling.

The smallest vapour plants of standard size have a vapour bath 20 in. long by 9 in. wide by 15 in. deep ; they are being used in surprisingly large numbers. The largest plants of this same type are those being used to prepare batches of motor-car mudwings for those anti-rust processes which are in such wide use to-day. They are readily placed in a conveyer line for continuous process work. The longest plants made are those used in the processing of aeroplane wings.

Of the many and varied processes in connection with which degreasing is necessary reference was made to annealing, oil quench after heat-treatments, before sand-blasting, anti-rust processes, and electroplating processes, for which the trichlorethylene method has given every satisfaction ; but in such a widely applied process as degreasing it was only possible for Mr. Jesson to touch lightly on some of its many applications.

The subject is of much interest to-day in view of the high standard of finishes now demanded, for these cannot be produced where grease is present, and modern finishes, with their excellent appearance, their easy maintenance, and their high protective power to the base metal, require that this, in the first place, shall have been subjected to modern degreasing.

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Contributions suitable for the editorial pages are invited. Photographs and drawings suitable for reproduction are welcome. Contributions are paid for at the usual rates.

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OURSELVES AND THE U.S.A.

It is regrettable that the United States should call upon the various debtor nations to resume war debt payments just when a slight recovery in trade seemed to indicate beneficial effects from the Hoover moratorium and from the results of the Lausanne Conference. It is probably unfortunate that the expiration of the moratorium occurred in July last, when the United States were beginning to feel the force of political influences imposed by the impending presidential election. Apart from this, however, the severe internal crisis in America, coupled with an unemployment problem of an acute character, created a position in which the Americans were naturally loath to favour revision of the present agreements.

It is, of course, futile to remind the American public of statements made by some of their responsible politicians about the time Great Britain was receiving these loans, in which hopes were expressed that they would never ask back a single cent. The conditions have changed, and the position has become increasingly difficult. At that time America, industrially and commercially, was on the wave of prosperity; since then, however, her activities in these directions have become almost lifeless by comparison, and her estimated budget deficit has reached alarming proportions. But all right-thinking Americans will appreciate that these loans were made in goods and materials, and the effect of the American tariff has been to restrict the import of manufactured goods which the United Kingdom produces, thus payment of the debt in this way has been impossible. Actually, the British debt is expressed in terms of gold, but the burden is measured in terms of sterling. Thus the payment of the amount due, under the Funding Agreement, represents, in terms of goods, not less than double the amount which was borrowed.

The Notes that have passed between the respective Governments, while they have not increased the difficulties, have not resulted in any modifications. A powerful argument for the revision of the war debts in general is that put forward by the British Government when it expressed the conviction that a resumption of war debt payments as they existed before the Hoover moratorium would deepen the depression in world trade, and would lead to further falls in commodity prices, with disastrous consequences from which no nation would be exempt. Congress was, however, adamant. The difficulty of the position was increased by the want of effective authority in the United States to deal with an urgent problem of this kind.

The decision to honour the obligation—a decision that was never in doubt—was coupled with a condition that while payment would be made in gold, the amount should be set off against final settlement, and that annual payments were not to be resumed. There can be no doubt that this also expressed the unanimous opinion of the British public, but Mr. Hoover and his advisers had no authority to accept this provision; Congress could not sanction any such compromise, and payment was asked under the terms of the Funding Agreement.

No one can take exception to the tone of the American Notes, but payment of the amount due was urged, after which Britain will have every right to ask and to expect a complete reconsideration of the whole problem. Between this country and America there is a long record of difficult disputes surmounted by friendly discussion. No two countries are better fitted to arrange a practical compromise that will satisfy both points of view. We should despair of all international understandings if the present emergency should in any way interfere with the existing friendship which is unique among the nations of the world. Yet, despite the friendly tone of the Notes and the good feeling that exists between the countries we think that some condition could well be associated with the payment that would definitely determine a basis for a reconsideration of the whole problem. It is the primary cause of the present stagnation in trade, and without some compromise no progress can be made.

Whatever may happen as a result of these extraordinary exchanges between this country and America, it is difficult to contemplate the revival of the old system of debt payments. Evidently the Government has in mind a final settlement that will involve a lump sum payment, since cancellation is apparently out of the question; certainly some arrangement must be made at the earliest possible moment in order to remove the uncertainty, which is further retarding trade recovery.

The revival of confidence, which was a direct result of the Lausanne Conference, gave indications of economic improvement, but the ratification of agreements made at this Conference really rests with America, and although apparently Britain, at present, does not intend to call upon her European debtors, the idea that she can continue to make regular payments to America under the Funding Agreement, without calling upon her debtors, cannot be contemplated. If the results of the Lausanne Conference are to have any value at all, a speedy compromise with America is imperative.

The further inflow of gold to America as a result of these payments does not improve trade, rather does it tend to accentuate the present uneven distribution of the world's gold reserves, and recovery is only possible from natural revival of trade that is world-wide in effect. A continuance in the payments of debts really involves a one-sided development of trade which, in the present state of depression and unemployment, should be avoided.

One of America's leading economists, Dr. B. M. Anderson, made the position clear in a recent address, when he said that it was to the economic advantage of the United States to consider the whole question to defer payments for a time and to scale down schedules for future payments in many cases. War debts, he declared, have violently disturbed trade and credit at home and abroad, and the inter-governmental debt fabric is one of the major causes of depression. On the economic side, the business-like compromise on the debt question which will get the question out of the way, restore world confidence, and permit restorative forces to move in reviving credit and trade and in lightening unemployment.

We hope when payment is made the British Government will maintain that the payment is made without prejudice to the case of either side, but that a revision of the agreement is essential and should be tackled without delay. Only in this way is it possible to remove the uncertainty which the question has again raised, and the depressing influence from the basic industries in this country, especially the iron and steel industry.

A BESSEMER STEEL SCHEME.

THE development of the Bessemer process had a revolutionary effect on the steel industry, not only in Great Britain, but in all the industrial countries of the world, as from 1859 onwards the process was adopted wherever steel for general constructional purposes was produced. Its development resulted in the introduction of what really amounted to a new metal—mild steel,—which could be substituted for malleable iron at less than a third of the cost of previous methods, and it is not surprising that the process was largely responsible for rapid development in the iron and steel industry.

Important, however, as the process has proved from an economic and technical point of view, it has serious limitations in practice, due to lack of uniformity in the quality of the steel manufactured. Rapid developments in various branches of engineering created a demand for the highest possible quality of materials, and in order that steel would meet the more exacting requirements, the manufacture of steel by the open-hearth process was developed. Despite the fact that the open-hearth process is more costly, the Bessemer process has been gradually dropped in its favour, because of the superiority of the steel produced; in fact so great has been the change in Great Britain that the Bessemer process has been almost completely superseded by the open-hearth process since some years before the war, and steel manufactured by this process is now excluded from British standard specifications. During this time, however, the Bessemer process has continued on the Continent, and because of the relatively low cost of manufacture by this process, large quantities of Bessemer steel have been imported into this country at a very low price. For some years it has been contended that sufficient iron ore of suitable quality exists in this country for steel manufacture by the basic Bessemer process, and that for economic reasons efforts should be made to restore the process as a means of meeting the requirements for cheap steel rather than to allow Continental countries to have a monopoly in exploiting the British market.

In view of the many discussions on the subject during recent years, the important development decided upon by Messrs. Stewarts and Lloyds, Ltd., is of special interest. The directors of this company have for a number of years recognised the great potential value of the Northamptonshire deposits of iron ore, which, by adopting a suitable process, would enable steel to be produced at a cost comparable with that of Continental steel. The results of full-scale experiments and exhaustive trials have convinced the directorate that this ore is particularly suited for the manufacture of steel by the basic Bessemer process, and steel-making plant of this type is to be erected at Corby, in Northamptonshire. The decision has been made possible by the foresight of the directors of the firm in adopting the policy of extending and consolidating the company's holding of Northamptonshire ores until reserves in its control are stated to be 500,000,000 tons.

Financial support for the scheme, which will cover the cost of construction of the new plant, including that spent in ensuring ample iron-ore deposits, has been given by a powerful group through the offices of the Bankers Industrial Development Co., Ltd. Arrangements have been made whereby £3,300,000 will be advanced as a loan on terms which are advantageous to the steel company.

The results of this venture will be watched with more than ordinary interest, not only by steel manufacturers in this country, but by those abroad, particularly on the Continent, from whom we have become accustomed to receive supplies. Messrs. Stewarts and Lloyds are to be congratulated on their courage in developing a scheme of such importance at this time; it is an indication of confidence that might well encourage other sections of the iron and steel industry to give effect to schemes under consideration.

The Salter Report.

THE recommendations of the Salter Committee for largely varied taxation of heavy road vehicles is having disastrous consequences on motor and electrical construction. Negotiations that have been in progress with various undertakings for up-to-date petrol and trolley 'buses, contemplated as replacement transport facilities, have been stopped. Throughout the country orders for new vehicles are being suspended owing to the anxiety created by the absence of a plain declaration by the Government. The need for a fair basis for rail and road competition is urgent, and should be established without delay.

In view of the contentious character of the problem presented by rail-road competition, the article on the subject in this issue by Mr. T. F. Braime will be read with particular interest. The problem has arisen as a direct result of the rapid growth of motor transport, which has caused a diversion of traffic that formerly went by rail. Each type of transport has now become a necessity, and must be organised to run side by side; this fact must be appreciated in order to reach an amicable solution.

FORTHCOMING MEETINGS.

THE INSTITUTION OF MECHANICAL ENGINEERS.

Jan. 13. "The Compression-Ignition Locomotive and its Applicability to the British Railways," by Lt.-Col. L. F. R. Fell, D.S.O., M.I.Mech.E.

NORTH-EAST COAST INSTITUTION OF ENGINEERS AND SHIPBUILDERS.

Jan. 13. "Radiation of Boiler Furnaces," by W. T. Bottomley.

THE INSTITUTION OF ENGINEERS AND SHIPBUILDERS IN SCOTLAND.

Dec. 20. "Engineering Research at the National Physical Laboratory," by H. J. Gough, M.B.E., D.Sc., Ph.D.

THE INSTITUTE OF METALS.

BIRMINGHAM SECTION.

Jan. 19. "Moulding Sands," by J. G. A. Skerl, D.Sc.

LONDON SECTION.

Jan. 12. "The Zinc Industry," by Stanley Robson, M.Sc.

NORTH-EAST COAST SECTION.

Jan. 13. "Corrosion of Metals in Salt Solutions and Sea Water," by G. D. Bengough, M.A., D.Sc.

SCOTTISH SECTION.

Jan. 16. "Aluminium-Bronze," by F. Hudson.

SHEFFIELD SECTION.

Jan. 13. "Metal Spraying," by Kenneth Gray.

THE INSTITUTE OF MARINE ENGINEERS.

Jan. 10. "The Running and Maintenance of Marine Diesel Engines," by N. E. Thompson.

THE INSTITUTION OF WELDING ENGINEERS.

Dec. 21. "The Essentials of Good Welding," by A. G. Walker, at the Institution of Mechanical Engineers, London.

INSTITUTE OF BRITISH FOUNDRYMEN.

EAST MIDLANDS BRANCH (LINCOLNSHIRE).

Jan. 7. "The Application of Pulverised Fuel," by W. Boon

LANCASHIRE BRANCH.

Jan. 7. "The Effects of Phosphorus on Low Total Carbon Cast Irons," by W. West.

BURNLEY SECTION.

Jan. 12. "Scrap Castings—Common Faults in Common Practice," by A. Jackson.

LONDON BRANCH.

Jan. 12. "Cost Accounts for the Light Casting Iron Foundry," by A. Young.

MIDDLESBROUGH BRANCH.

Jan. 13. "Notes on the Cause and Prevention of some common Defects in Steel Castings," by C. Howell Kain.

SCOTTISH BRANCH.

Dec. 17. "A Talk on Contraction," by J. Simpson. (At Edinburgh.)

Jan. 14. "The Sand Spun Pipe Plant of the Staveley Coal and Iron Co.," by J. B. Allan.

WALES AND MONMOUTH BRANCH.

Jan. 7. "Some Aspects of Oil Engine Foundry Practice," by H. E. Beardshaw. (At Newport.)

THE STAFFORDSHIRE IRON AND STEEL INSTITUTE.

Jan. 10. "Recent Coke Researches," by R. A. Molt, M.Sc., F.I.C. (At Dudley.)

THE RAIL-ROAD PROBLEM.

By T. F. Braime.

IN view of the many observations and recommendations that have been received by the Ministry of Transport, it is very unlikely that the Salter Report will be wholly accepted. No one can deny, however, that a very difficult problem exists between rail and road transport, and the sooner an amicable solution is reached the better. The problem is undoubtedly a direct result of the enormous growth of motor transport, which has caused a diversion of traffic that formerly went by rail, and there is a feeling that the railways are deliberately trying to limit the application of the newer form of transport in order to recover some of the lost traffic and to retain that which they already have.

The railways are unquestionably a national asset, and whether they remain in private hands or are nationalised, they cannot be allowed to perish ; on the other hand, they should not be allowed to hamper the development of the newer form of transport. Each type of transport has become a necessity, and must be organised to run side by side, because each has its own special function to perform. It is, therefore, of vital importance that the national interest must predominate, and the broad view be taken in arriving at a solution of the problem.

To try to stop the progress of the motor industry would not only be foolish, but it would be futile. Instead of making restrictions to interfere with this industry it would seem to be sounder sense to free the railways from the many restrictions they are under. We have seen the motor industry develop in the United States, unfettered by pettifogging restrictions, so rapidly that it has become the second largest industry in America, employing, before the slump, over three millions of its people, with colossal exports of its cars to all parts of the world. To cripple the growing industry of the production of heavy motor vehicles in this country for the home market and abroad by any restrictions would be a crime.

Britain is to-day producing the finest buses and motor-lorries in the world, with a vast potential market overseas. There are no limits to the use of motor transport, its application is not confined to tracks, it can reach every nook and corner of the world, and, since its use is now universal, it is most likely to outlive other known forms of transport for goods and passengers.

The development of motor transport has been a special boon to the farmer ; the motor-lorry is driven into the farmyard or field, loaded, and then taken direct to destination. It has provided a form of evolution which it would be madness to attempt to suppress.

The question of damage to main roads by heavy motor transport has been stressed by many who have given the subject careful thought, but this can be mitigated and almost entirely overcome in many ways. For instance, the substitution of pneumatic tyres of large diameter for solid tyres would have a considerable influence in increasing the serviceable life of roads. The same can be said for the use of six or more wheels, so that each wheel carried its limited load.

According to exhaustive tests which have been carried out in the United States, an 8¾-ton six-wheel truck with pneumatic tyres gives an impact on the road surface of 7,000 lb. A four-wheel 5-ton truck with pneumatic tyres gives an impact of 11,900 lb., whereas the same truck fitted with solid tyres gives an impact of 29,000 lb. Again, a 2-ton truck with four wheels fitted with solid tyres gives an impact of 21,900 lb., whereas the same truck fitted with pneumatic tyres, by comparison, has an impact of only 7,300 lb. The results of these experiments, if correct, clearly indicate that solid tyres should be superseded by pneumatics.

As a railway shareholder, keenly anxious for the welfare of our railways, I feel we must face the facts and strive or better organisation of our railways by insisting that they shall be free from many of the restrictions under which they are at present labouring.

The fact that the market value of the capital invested in the railways has depreciated so much, is not due entirely to the competition of motor transport, but is a direct result of the world depression. One has only to visualise the enormous number of ships laid up in our ports to grasp the big drop in our imports and exports of goods and raw materials, the great bulk of which goods are normally carried by rail, both inwards and outwards to and from port. Further, owing to the abnormal import per annum of approximately three million tons of steel instead of making it ourselves, this has deprived the railways of thirty millions of tons of traffic, comprising material such as iron ore, coal, coke, lime and basic slag required to make it.

Large sums of money have been sunk in new plant and extensions by the railway companies since the grouping took place, to manufacture for themselves new engines, carriages, waggons, and other equipment, which the separate companies, large and small, previously bought largely from the private manufacturers. The evil consequences of this policy are being realised ; not only is much of this plant idle, but the men drawn from other centres to work it are frozen around the railway shops, and have to be otherwise supported. For instance, the steel-rail mills put down at Crewe are being closed down, and future requirements are to be put out to contract. I maintain that it would be common sense to revert to the old custom of buying the bulk of new equipment by competitive tender, as and when it is required, thus avoiding the heavy overhead charges incidental to all manufacturing, where the incentive of personal gain is more or less absent.

In my opinion, the railway managements should concentrate on the purposes for which they were established—that is, the conveyance of goods and passengers from point to point at the lowest possible cost to the community, commensurate with a reasonable profit to the shareholders, under proper safeguards to the public, and under the minimum of restriction, Government or otherwise.

It is a welcome sign to note how the loss of traffic has recently awakened the railway managements to the necessity of faster goods trains ; the cutting out of redundant services ; their willingness to explore the possibilities of the Diesel and other types of locomotives now being developed by the private makers ; the use of motor-lorries for the collection and distribution of goods ; the provision of large-capacity all-steel railway wagons for the movement or iron ore, coal, and raw steel from production to consumption centres, etc.

Railway freight rates which are 60% above pre-war, fixed under arbitrary rules, should receive drastic revision. There is no sense in fixing a rate based upon what it is thought the industry will bear. The rate should be based upon cost. As an instance, coal is carried from South Yorkshire to London for 10s. 6d. per ton, plus wagon hire, whereas steel bars from Frodingham to South Wales costs 20s. 8d. per ton. There is no equity in that, and the potential movement of large quantities of steel bars to South Wales to take the place of the imported bars now shut out, will require careful consideration by the railway companies. The policy of high rates for short-distance traffic and low rates for long distance has recently been reversed by one of the South American railways, with beneficent results to the company. It should have a similar effect here.

Motor transport can be a valuable auxiliary feeder for railways, not alone in Britain, but more still in our Colonies and foreign countries, and to interfere with the development of the industry by repressive legislation, beyond the ordinary safeguards required for the protection of other users of the roads, and the mitigation of damage to roads, would be a blunder of the first magnitude. It would be a national loss of export trade if the proposed increased taxation and restrictions in any way prejudiced the development of the industry.

Aluminium Sheet Production

By Robert J. Anderson, D.Sc.

Part XIV.—Cold-Rolling Mills.—Contd.

Rolls for Cold-rolling Mills.

VARIOUS kinds of rolls have been used in aluminium cold-rolling mills, including plain chilled cast iron, chilled alloy iron, cast steel (hardened), and forged and heat-treated alloy steel rolls. Ordinary chilled cast-iron rolls have been used extensively in American aluminium practice on both sheet and coil mills. The forged and heat-treated alloy steel roll is a development of Continental Europe, and it has been employed more abroad than in the United States. There is no gainsaying the general superiority of the forged-steel roll over all other types; the chief deterrent to its wider use is high first cost. When used for cold roughing and finishing operations on aluminium sheet and coil, plain chilled cast-iron rolls last for long times. Life may be dependent in large part on the number of grindings or dressings required to remove coatings, markings, or scratches, or for the purpose of special shaping. A minute, or in some cases appreciable, layer is removed from the surface of the roll on dressing, so that ultimately the end of the chilled rim is reached. Usually, the roll is to be discarded when about three-fourths of the chill depth has been taken off. Of course, the serviceable life of a chilled roll may be considerably decreased if pinholes are uncovered on dressing. Sometimes a layer $\frac{1}{8}$ in. to $\frac{1}{4}$ in. thick must be ground off a roll in order to remove a spongy place. When used for cold rolling, chilled rolls are not subject to cracking and surface fissuring, as is the case when they are used for hot-rolling aluminium.[9]

For finish rolling bright flat aluminium sheet and coil, forged steel rolls are preferable to the chilled cast-iron variety, since better surface finish can be obtained with the former. Cast-iron rolls are to be used in rolling grey plate; they pick up a coating quicker, and hold it better than do steel rolls.

In a previous article[10] (Part X.), the composition and hardness of rolls have been given. The discussion in that article was concerned rather more with rolls for aluminium hot mills, but in a general way it applies also to rolls for cold mills. Forged and heat-treated steel rolls are often made of chromium steel or nickel-chromium steel. They are considerably harder than chilled-iron rolls.

On two-high mills built by the Fraser and Chalmers Engineering Works of the General Electric Co., Ltd., rolls are made of chilled iron when the neck stress is not too great[11]—that is, they are applied on mills fitted with journal bearings, and on large mills fitted with roller bearings. Hardened steel rolls are recommended for small two-high mills fitted with roller bearings on account of the increased neck stress. In the case of four-high and cluster mills built by this company, working rolls for cold rolling are made of nickel-chromium steel. Backing-up rolls are made of plain chilled iron, alloy cast iron, cast steel, or forged steel. Chilled cast iron is recommended for use where the neck stresses are low and alloy cast iron or cast steel are used where the neck stresses are heavier. Forged steel is best where heavy stresses are encountered, but owing to its high cost it is used chiefly for small and medium-size rolls.

Aluminium sheet-mill rolls are not ordinarily water cooled by internal circulating water, but the rolls of high-speed, two-high strip mills may be so cooled. Special fittings are provided for leading water under pressure into the passage in the roll via the end of the neck. Fig. 14 shows a fitting attached to the rolls of a small finishing mill. As mentioned previously, the working rolls of backed-up mills may be provided for internal water cooling.

In designing rolls, the lengths and diameters of the bodies and of the necks must be suitably proportioned. The design is governed by various factors, including the composition and strength of the roll material, type of mill, kind of bearings, lubrication method, speed of rotation, nature of the rolling process, etc. Some roll sizes have been given earlier in this article, which indicate body proportions. With the development of backed-up mills, there

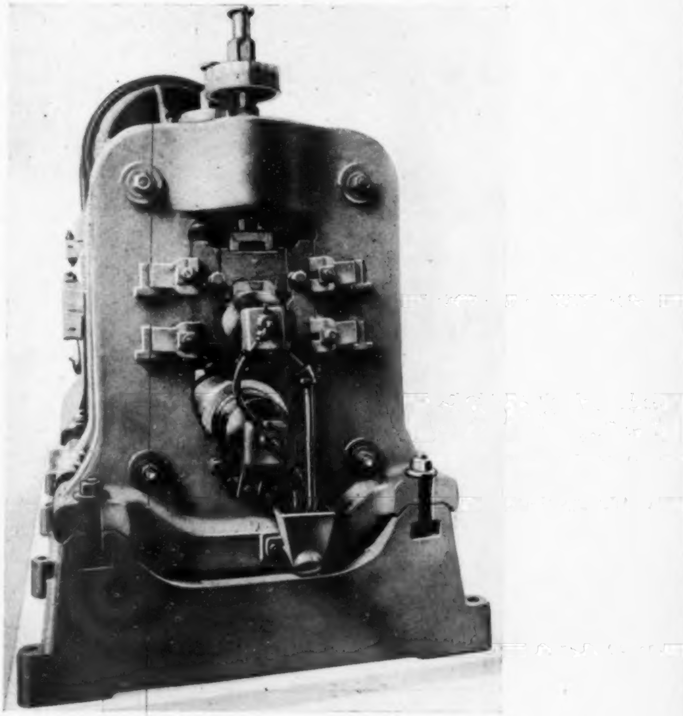

Fig. 14.—Water cooling attachment on strip mill. (Philadelphia Roll and Machine Co.)

has been a tendency with some builders to supply two-high strip mills with chunky rolls—the face length equal to the diameter or only a little larger. Such rolls have inappreciable flexure, and are ground flat—*i.e.*, with no crown. Neck proportions of rolls should be ample for support, and to provide effective bearing surface. The diameters of necks of rolls fitted on two-high sheet and strip mills vary from about 0·6 to 0·8 of the diameters of the rolls. As an example, rolls measuring 24 in. in diameter by 60 in. in face length may have necks 16 in. in diameter.

In ordering spares from a roll-maker, blueprints of a drawing like that shown in Fig. 15 may be used for convenience. The proper dimensions are entered in the blank rectangular spaces of the drawing.

A bibliography on rolls has been prepared by Polansky,[12] which is a good guide to the literature of the subject. Roll-grinding and dressing will be discussed in a later article dealing with repairs and maintenance in the aluminium rolling mill.

9 R. J. Anderson, "Aluminium Sheet Production. Part X.—Hot Mills," *Metallurgia* vol. 5, No. 25, November, 1931, pp. 21-22.

10 R. J. Anderson, *loc. cit.*

11 Anon., "Fraser and Chalmers' 'Bliss' Rolling Mills," *Metallurgia*, vol. 3, No. 17 March, 1931, pp. 191-192.

12 V. S. Polansky, "Rolling-mill Rolls: A Bibliography," Carnegie Library of Pittsburgh, 1929, Pittsburgh, Pa., 59 pp.

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Rolling-mill Bearings.

During the past ten years much attention has been given to the design and performance of various types of bearings for rolling mills, particularly for roll necks, but also for pinion and gear shafts, and for other rotating elements. At the same time, the lubrication of bearings has been studied at considerable length, and several new systems for delivering oil or grease to bearing surfaces have been devised. As is well known, the old-time rolling mill was a highly inefficient machine, some 50 to 60% of the drive power being consumed in overcoming roll-bearing friction. Losses at other points in the pinion stand and reduction unit so reduced the efficiency that only 10 to 20% of the applied power was utilised in rolling metal. Rolling mills fitted with conventional mill brasses or babbitted journal bearings, lubricated by poking grease around the roll necks, operate more or less satisfactorily as slow-speed machines—or, at any rate, do not give serious trouble in operation, despite their relatively low efficiency. When, however, the rolling speed is much increased, this type of bearing, lubricated as mentioned, overheats and fails to stand up, so that replacement and maintenance costs are high. Apart from increased wear of bearings and loss of power, hot roll necks give rise to various troubles with the rolls, and cause inaccuracy in the product—*i.e.*, non-uniformity of gauge. Davies[13] has said, "It is no exaggeration to state that until a really efficient roll bearing and lubrication system was available, the economy of higher rolling speeds was at least doubtful." This is an eminently fair view of the situation.

Any detailed discussion of bearings for roll necks, pinion and gear-shafts, and other parts of rolling mills is beyond the scope of this article. In purchasing new mills or revamping the bearings of existing units. it is well to be guided by the recommendations of builders, past experience, and the most recent developments.

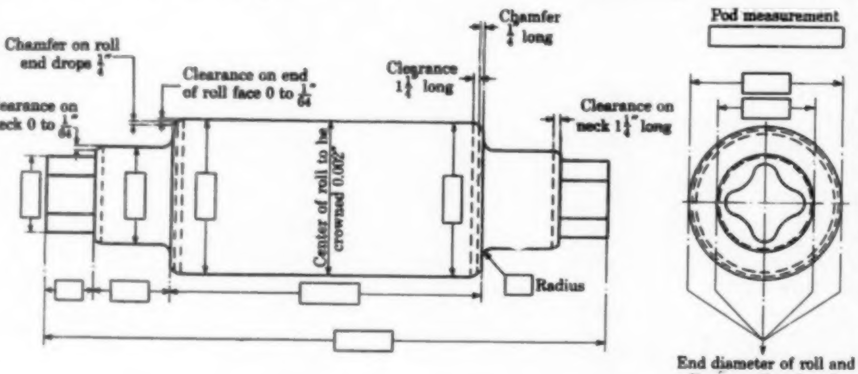

Fig. 15.—Form of typical roll.

Plain roll-neck bearings of the journal type are generally made of leaded bronze or phosphor bronze, and nickel-bearing bronzes have been used for these bearings of recent years. Provision may be made for internal water cooling or not. Reversing strip mills built by the Fried. Krupp Grusonwerk, described previously in this article, are fitted with water-cooled roll-neck bearings. The bearing steps are not bored, but have cast-in channels in the outer shell, these being fitted within the chocks, so that there is no water leakage. The bearing caps are so designed that the roll necks are continually washed by the cooling water. With this arrangement, the bearings do not need to be so heavy as in usual designs, and are less expensive. A central lubricating system is provided, with forced oil feed, which automatically cuts out when the mill is stopped. Water-cooled roll-neck bearings are also supplied on the strip mills built by Schmitz and Co., previously mentioned; lubrication is by forced feed.

An interesting and efficient type of roll-neck bearing and lubrication system for strip mills has been described by Davies.[14] This was developed a few years ago by Davies and Bourne, and is known as the "Flood" system. It has been installed on mills built by W. H. A. Robertson and Co., Ltd., Bedford, England, and has given excellent results. The bearings are made of bronze or may be babbitt lined. Each bearing totally encloses the roll neck, thereby preventing the entrance of dirt and other foreign substances. The loaded side of the bore serves as the bearing surface, and the unloaded side provides a chamber which is maintained full of oil. Rotation of the neck carries the oil on the surface between it and the bearing. The entry edges of the bearing portion are tapered to facilitate entrance of the oil. A large volume of oil at low pressure is continuously pumped, from 2 to 5 gals. being circulated per minute. The oil is returned to a reservoir, after passing through strainers, and is cooled by a pipe coil. Generally, the bearings are provided with passages and fittings for water cooling, but this is not ordinarily necessary and may be omitted on small mills. Oil is circulated by a rotary pump chain driven from a shaft of the mill drive; a separate line delivers the lubricant to each bearing through visible feed cups. Very substantial power savings have been effected by the use of these bearings on high-speed mills.

In passing, it is of interest to point out that micarta, a phenolic resinous material of high strength, has been tried with good results as a bearing liner in various types of rolling mills. Water alone is used as the lubricant. Rohn[15] has discussed recent developments in bearings for non-ferrous rolling mills.

The use of roller bearings on roll necks has been gaining ground rapidly of late, not only for backed-up mills, but also for two-high strip mills. Roller bearings present great advantages in power economy, savings of upwards of 50% being effected as against bronze journal boxes of the usual type. Neck heating is eliminated, and lubrication costs are greatly decreased by the use of roller bearings. At the present time, roller bearings are not ordinarily applied on two-high sheet mills or on two-high strip mills used for heavy work; journal bearings are preferred on these mills when chilled-iron rolls are used, because of the necessity of carrying a large neck. Some rolling-mill builders are equipping their two-high finishing strip mills with roller bearings. One disadvantage in using the roller bearing arises in the necessity for carrying a rather small neck diameter—on account of the desire to minimise the size of the bearing and hence lower its cost, space limitations, and other factors. As the situation now stands, two-high mills fitted with roller bearings have less capacity than when equipped with journal bearings, so that a bigger mill is required to do the same work on a given width of metal. Generally speaking, it is impractical to attempt to substitute roller bearings for journal bearings on existing two-high mills. The limited space available precludes the use of roller bearings sufficiently large to carry the pressures. The new types of backed-up mills are fitted with roller bearings by all builders.

The application of roller bearings to roll necks has been discussed by Gainsborg[16] and Van Campen,[17] among others.

Roller bearings are being applied on reduction-gear

13 C. E. Davies, "Roll Bearings for Cold-rolling Mills," *The Metal Ind. (London)*, vol. 35, 1929, pp 459-462; 496-497.

14 C. E. Davies, *loc. cit.*; and elsewhere.

15 W. Rohn, "Gleitlager an Walzwerken," *Zeit fur Metallkunde*, vol. 23, 1931, pp. 76-83.

16 E. C. Gainsborg, "Developments in the Application of Anti-friction Bearing to Roll Necks," *The Rolling Mill Journal*, vol. 3, 1929, pp. 19-22.

17 J. H. Van Campen, "Selection of Anti-friction Bearings for Roll Necks," *The Rolling Mill Journal*, vol. 3, 1929, pp. 31-34.

units and on pinion stands with good results. It appears that roller bearings will continue to find increasing use on rolling mills and drive units.

Rolling-mill Drives.

The method of driving rolling mills is an important matter for consideration both in laying out new plants and in adding equipment or bettering conditions at existing works. In present-day practice, aluminium rolling mills are ordinarily driven with power supplied by electric motors, transmission being through some kind of reduction-gear unit. The motor should be connected to the speed reducer by a good flexible coupling. This corrects any misalignment and absorbs shocks and torsional vibration. In the ordinary drive of single-unit, two-high mills, the slow-running shaft of the speed reducer is coupled to the lower pinion of the pinion stand. Drive for the upper and lower rolls of the mill is then obtained by means of spindles connecting the rolls and pinions. For train drive, the reduction-gear unit may be connected to a pinion stand or coupled directly by means of a spindle to the lower roll of the first mill. In the latter case, a pinion stand is suitably disposed in the train. Reduction-gear units may be of the spur or herring-bone type, the latter being more expensive, but much better suited for rolling-mill drive.

Aluminium rolling mills may be individually driven by motor, or a considerable number of mills may be hooked-up in a train—all driven by one motor. Train arrangement is adapted, and is used for slow-running, constant-speed units, particularly flat-sheet mills. However, coil mills are sometimes driven in train. The chief advantage of train drive is economy in first cost of installation as compared with drive by individual motor. Train drive,, however, presents a serious disadvantage in lack of flexibility, and may be more expensive in the long run. A failure or some trouble on one mill in a train will cause at least temporary shut-down of the whole train; or, in some cases, part of the line-up must be cut out of operation until repairs are made. Also, in case of trouble with the drive, the entire unit is put out of commission. On the other hand, with individual drive, only one operating unit is affected in case of failure or when necessary repairs are required. At one plant 16 aluminium sheet mills are run in a train, eight mills being placed to the right and eight to the left of the drive unit. There is a pinion stand between the fourth and fifth stands on each side of the drive. In the same plant, eight coil mills are run in a train; the drive is at one end of the line-up, and four mills are placed at the right and four at the left of the pinion stand. Recent practice favours individual motor drive for two-high, non-reversing strip mills. Two-high, reversing strip mills and multiple-roll mills are normally driven by individual motor, although three-high units are sometimes run in a short train.

The drive features of various mills as supplied by different builders have been briefly referred to in previous paragraphs of this article. Davies[18] has described the drive of late-type high-speed strip mills as built by W. H. A. Robertson and Co., Ltd. In the construction, the drive is of the usual type from pinions to rolls by machined and balanced spindles and coupling boxes. The pinions are made of steel, and have machine-cut double-helical teeth. They are mounted in totally enclosed housings, and have automatic lubrication to the bearings. The pinion teeth have fine pitch, so as to prevent vibration, which might cause marking of the strip. The gears of the reduction unit are made of steel, and have machine-cut double helical teeth. These gears are totally housed in a case which forms an oil reservoir. The gear teeth are lubricated by oil sprays from a pump. Gear shafts are made of high-tensile steel, and run in roller bearings. A friction clutch of the multiple-plate type is mounted in the gearcase; this is operated by levers and permits stopping and starting of the rolls independently of the motor. The motor is connected to the clutch-shaft by means of a flexible coupling.

Fig. 16 shows a view of a two-step reduction-gear unit, with the housing cover removed, for a three-high mill.

Variable-speed drive for individual mills is desirable, and increases the flexibility and usefulness of the equipment. Where a number of medium-size adjustable-speed drives are required in a plant—as where a battery of coil mills is to be driven,—it is generally more economical to use D.C. motors and furnish power by motor-generator sets of synchronous converters. Horsepower demands naturally vary greatly, depending on the size of the mill and the work to be done.

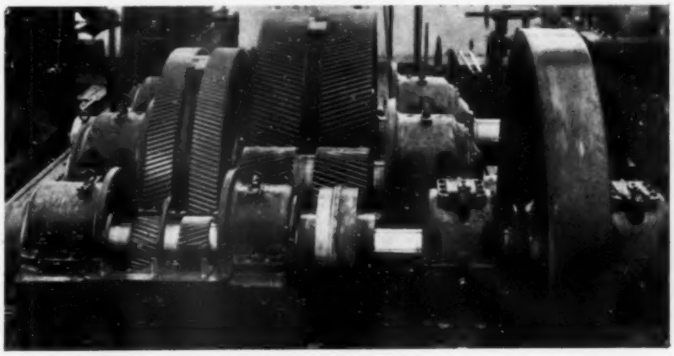

Fig. 16.—Reduction-gear unit for three-high mill. (Engelhardt Achenbach sel. Söhne.)

18 C. E. Davies, "Development in High-speed Strip Rolling," *The Metal Ind. London*), vol. 33, 1928, pp. 413-416.

Dynamic Strength of Light Alloys.

DATA on the static (tensile, compression, shear, torsion, transverse, and hardness), and dynamic strengths (impact, reversed bending, and torsional) of eight light alloys, two of which were in the as-cast conditions, are given by K. Matthaes, in the August issue of *Zeitschrift fur Metallkunde* Tests made in the temperature range of from $-180°$ to $+100°$ C. revealed the fact that the notched bar impact strength of aluminium alloys (duralumin, lautal, aeron increases with decreasing temperature, whereas with the Mg alloy tested (Elektron) the reverse is the case. This cold shortness of the latter alloy is also exhibited in the appearance of the fracture. The reverse bending tests, which were carried out on a Schenck machine, showed that a classification of the light alloys according to the stress endured after 10^7 cycles, is not correct. Thus, after 50,000 stress reversals, the strengths of the duralumin alloys did not differ greatly from each other ($16{\cdot}7 \pm 0{\cdot}9$ t./sq. in.). With increasing number of cycles the stress-endurance curves diverged more and more, the difference between the highest and the lowest curve attaining a maximum value after 2×10^6 stress reversal ($4{\cdot}8$ t./sq. in.). Then the curves converged and, after 5×10^7 cycles, gave about the same strength for all the alloys tested ($8{\cdot}8 \pm 0{\cdot}9$ t./sq. in.). Therefore, in assessing the value of a light alloy the entire course of the stress-endurance curve must be considered. Of the Al-alloys tested only the alloy aeron showed a well-defined fatigue limit ($7{\cdot}8$ t./sq. in.). Additional static (tensile or compression) stresses did not affect the dynamic strength of this alloy, whereas the strength of elektron was decreased from $9{\cdot}5$ to $6{\cdot}0$ t./sq. in. by additional tensile stresses. Further, elektron is more sensitive to notch effects than the Al-alloys. The reversed torsional tests which were made on a MAN machine, showed that a high reversed bending strength is not always associated with a high torsional strength. The corrosion-fatigue of duralumin could be markedly improved by anodic oxidation (Bengough process).

The Value of Soda Ash in the Iron Foundry

MODERN scientific control in the foundry is gradually effecting a remarkable change in the character of castings produced and the quality of metal used. Mass production of complicated castings has now come to be recognised as regular practice, and with metallurgical developments a degree of regularity of metal composition has been attained that indicates substantial progress. Uniform machining qualities with satisfactory resistance to wear, in addition to high mechanical properties, are necessary for modern service conditions, but the soundness of a casting is still one of its primary requirements. High-grade castings, capable of giving long service under varying conditions, are being increasingly appreciated by the engineer, and anything which is likely to facilitate their production is of special interest to foundrymen; the subject of the paper recently given by Mr. N. L. Evans[1] is therefore of considerable value. He discussed soda ash, which is so rapidly establishing itself in this country as one of the cheapest means of improving the quality of cast iron and helping it to meet modern demands.

Originally used as a desulphurising agent, this material has been found to have a marked refining and degasifying action on the metal. It helps in the production of sounder castings, which can also be more easily machined. Its use has become common in the manufacture of refined pig-iron and alloy pig-iron, heavy grey-iron castings, particularly those used in chemical plant, converted steel castings, malleable castings, and motor cylinder and other high-grade castings, which are required to withstand pressure.

Soda ash is available in two forms for foundry use. In the form of granular powder it is used in the ladle or receiver, being simply thrown into the bottom and the metal being tapped on to it. After allowing time for the reaction to take place, the fluid slag which rises to the surface is thickened with ground limestone and removed with a deslagging tool. In the case of large castings there is practically no increase in the time taken, as the metal frequently remains in the ladle for half an hour or more. The reaction which takes place is exothermic, and the fluidity of the iron is increased by the removal of sulphur. The main reactions may be represented by the following equation:—

$$\underset{\substack{\text{Sodium}\\\text{Carbonate}\\\text{(soda ash)}}}{Na_2CO_3} + \underset{\substack{\text{Manganese}\\\text{Sulphide}\\\text{Iron Sulphide}}}{\frac{MnS}{FeS}} = \underset{\substack{\text{Sodium}\\\text{Sulphide}}}{Na_2S} + \underset{\substack{\text{Carbon}\\\text{Monoxide}}}{CO} + \underset{\substack{\text{Sulphur}\\\text{Dioxide}}}{SO_2} + \underset{\substack{\text{Manganese}\\\text{Iron}}}{\frac{Mn}{Fe}}$$

Typical analysis of metal before and after treatment by the ladle method are shown in Table I., which indicates the effect of soda ash on sulphur and manganese contents.

TABLE I.

Before Treatment.		After Treatment.	
Sulphur, %.	Manganese, %.	Sulphur, %.	Manganese, %.
0·092	0·36	0·047	0·47
0·111	1·02	0·065	0·96
0·086	0·4	0·044	0·45
0·19	0·24	0·07	0·27
0·048	0·31	0·028	0·32
0·1	—	0·02	—
0·23	—	0·074	—

When time is a vital factor, as in the case where small hand shanks are filled direct from the cupola for making castings of thin section, or in casting white iron for malleable, which requires a very high temperature, then soda ash in the form of fused blocks is recommended. These blocks are added to the cupola charge at the same time as the limestone. This method is not quite so efficient as the ladle method, from the point of view of reduction of sulphur, but it has a very marked effect on the structure of the metal. Typical effects of this treatment on the sulphur content are shown in Table II.

TABLE II.

Before Treatment.	After Treatment.
0·12	0·07
0·06	0·048
0·093	0·08

Both forms in which the reagent is available consist of pure anhydrous sodium carbonate, and the amount used is usually 0·5 to 1·0% of the weight of iron treated. In the manufacture of refined iron, and in the converter steel process—two typical examples given by Mr. Evans—the actual removal of sulphur is of primary importance and, if this were the sole effect of the soda ash, it would still have a wide application. But the author dealt with some of the additional applications which bring the process within the range of interest of almost every foundry excepting where the lowest grade of work is done.

Experiments in which dirty scrap iron was melted and submitted to tests before and after treatment show that soda ash has a marked influence in promoting soundness in castings. Unsoundness may be due to many factors, amongst them being non-metallic inclusions of the manganese-sulphide type, which have a marked tendency to segregate; mechanically entrapped dirt; a high gas content; an open grain; and faulty design. Soda ash tends to ameliorate the defects arising from these causes.

The soda ash melts at about 850° C., and at the temperature of molten iron it forms a very fluid slag. In melting, an evolution of carbon dioxide takes place which causes the slag to boil, which agitates the metal, producing one of the most common methods of degasifying molten metal. Thus, when the ladle method is adopted the metal is degasified, whilst quite fluid, so that the amount of gas left to come out of solution during solidification is negligible.

The effect of the treatment on grain structure was shown to be beneficial. It tends to have a refining action on the graphite, and produces a metal which has a more uniform grain structure than similar metal untreated. The refining action also appears to affect the pearlite; and Mr. Evans stated it had been repeatedly noticed that pearlite in untreated iron can be readily resolved, but in treated metal an appreciably larger proportion is not resolvable.

It is generally agreed that the machinability of castings from a production point of view is a matter of considerable interest. There is a demand for the material to be supplied in its most machinable condition consistent with other requirements, such as resistance to wear. The sulphur contents of the iron should be kept low in order to control the degree of hardness, and this can be effected by the use of soda ash. Non-metallic inclusions of oxide and silicate in the metal also influence machinability; a large proportion of these inclusions which become mixed with the metal in the ladle is removed by the sodium carbonate slag, and, according to Miller, results in an increase in machinability of the treated metal.

Sufficient evidence is given by Mr. Evans to indicate that soda ash properly used has a very beneficial effect on cast iron, not only as a desulphurising agent, but in improving the material generally and in enabling it to conform more closely to modern requirements.

1 Paper presented before a joint meeting of the British Cast Iron Research Association and the London Branch of the Institute of British Foundrymen at Imperial Chemical House, London.

The Use of Small Roll Diameters and Development of Multiple - Roll Mills*

By Dr. W. Rohn, of Hanau-a.-M.

IN the rolling of thin sheets and strip under about 3 mm. to 2 mm. thickness, the conditions become more favourable the smaller the diameter of the working rolls, ignoring for the moment the bending of the rolls and the gripping capacity. The load to be carried by the housings, the power consumption, and the roll wear, are all reduced. A limit is imposed by the flattening of the rolls themselves at the line where they touch each other, so that for each diameter of roll there is a minimum thickness of the strip which can be obtained in practice—this for a two-high mill with 200 mm. diameter rolls being about 0·1 mm. or 0·08 mm. for soft steel single sheets or strip. The economical limit is about two to three times this minimum thickness.

The possibility of using heavier reductions and of reducing the final section by employing separate parts in the mill to perform the actual deformation and to prevent bending of the rolls was early recognised, although the successful development was only possible when roller bearings could be substituted for plain bearings, at least for the backing or supporting rolls.

While in a four-high mill the working rolls can be made as small as desired so far as bending in the vertical direction is concerned, no support is provided in the direction of rolling, so that for fine strip, 0·1 mm. thick and under, it is hardly possible to use a diameter of less than 80 mm. for rolls 250 mm. to 300 mm. long.

The use of a six-roll mill, Fig. 1a, with a pair of supporting rolls B for each working roll A, provides effectively against bending of the latter, both in the direction of rolling and at right-angles to it. This construction, however, limits the reduction in diameter of the working rolls, since when the ratio of this to that of the supporting rolls is less than about 1 : 2½ to 1 : 3½, the working roll A does not project sufficiently beyond the plane T, tangent to the supporting rolls B, Fig. 1b. With rolls 300 mm. long, it is therefore usual to make the working rolls not less than 120 mm. diameter, with supporting rolls 260 mm. diameter.

Whilst with four-high mills the working rolls must have journals or necks running in bearings to prevent them travelling in the direction of rolling, this is unnecessary with six-roll mills. The working rolls for the latter can thus be plain cylinders without necks if the supporting rolls are driven, very greatly decreasing the cost of them. The first cost of the mill is certainly somewhat higher owing to the greater reduction to be provided for in the gearing, by reason of the lower number of revolutions per minute of the supporting rolls. On the other hand, there is the advantage that the working rolls are only put in loose, and can therefore be changed in a few seconds.

In a recent method of construction the working rolls are driven, but are still plain hollow cylinders without necks, Fig. 2. They are placed loosely on the spindles, which are driven from the pinion housing, being only coupled to the spindles by means of a simple driving peg, to be seen at the left-hand end of the illustration. Since the working rolls are supported and guided by the backing rolls only, an appreciable gap can be left between the roll and spindle. The hole in the roll, therefore, does not need to be highly finished, nor exactly concentric with the outside, so that the cost of boring is not an important factor. The hole further reduces the risk of scrapping in hardening. The working rolls, being simply pushed on to the spindles, can be quickly changed. The supporting rolls can be carried on a stationary shaft with two roller bearings, see Fig. 3, which also shows provision for oil circulation.

The arrangement and accurate guiding of the upper sliding boxes in the usual type of mill housings represents a large proportion of the first cost, while they soon become worn and out of truth in service. A design is shown in Figs. 4 and 5, in which the distance between the rolls is adjusted by rotation around the bolt A, using the screw B. This is much cheaper than the normal type, owing to dispensing with the parallel guides, and there is practically no wear on the bolt A.

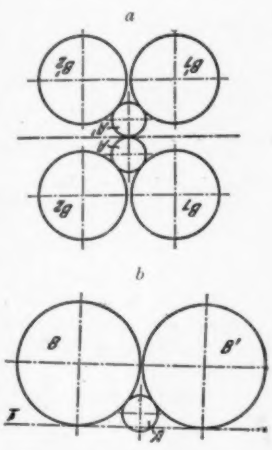

Fig. 1a and 1b. Arrangement of rolls in a six-roll mill.

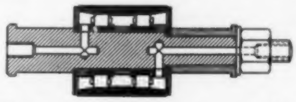

Fig. 3.—Arrangement of supporting rolls on a fixed shaft, with provision for cooling.

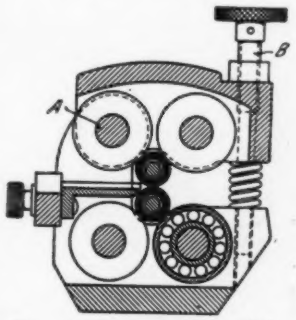

Fig. 4.—Upper rolls carried on a hinged arm.

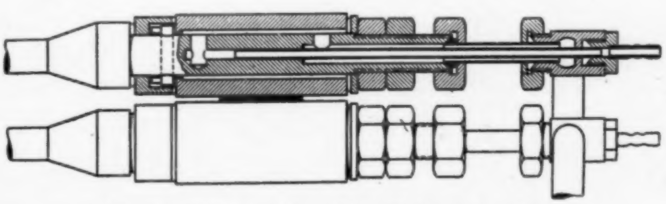

Fig. 2.—Hollow working rolls with internal cooling.

The construction which has been described is suitable for strip mills with rolls up to 450 mm. long and 150 mm. diameter. The cost of the working rolls is about one-third that of the former usual rolls with necks.

This construction has proved especially advantageous for very fine strip. With a mill having working rolls 25 mm. diameter by 60 mm. long, the supporting rolls being 55 mm. diameter, strip of soft steel, nickel, copper, etc., 35 mm. wide by 0·02 mm. thick can be produced without intermediate annealing below 1 mm. The thicknesses of successive passes are 0·5, 0·35, 0·2, 0·12, 0·07, 0·05, 0·035, 0·03, 0·026, 0·023, and 0·020 mm. In the production of the finest strip—*e.g.*, down to 0·3 mm. by 0·03 mm.—it is of benefit to use a coiler driven by a special small motor, giving very fine regulation of the torque, which can be maintained constant.

A description was given of a special continuous measuring device in which the strip is passed between diamond points, one of which is mounted on a diaphragm connected to a capillary tube fitted with maximum and minimum contacts,

* Abstract from *Stahl und Eisen*, August 25, 1932.

these being wired to signal lamps. The use of this has made possible the production of strip 10 mm. wide and 0·05 mm. thick, with a range of 0·002 mm. in the thickness and 0·02 mm. in the width. The strip is rolled with a slight excess in the width, this being removed by a small grinder placed in front of the measuring apparatus for the width.

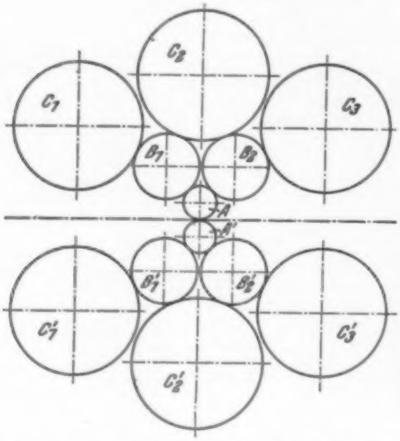

Fig. 5.—Arrangement of twelve-roll mill.

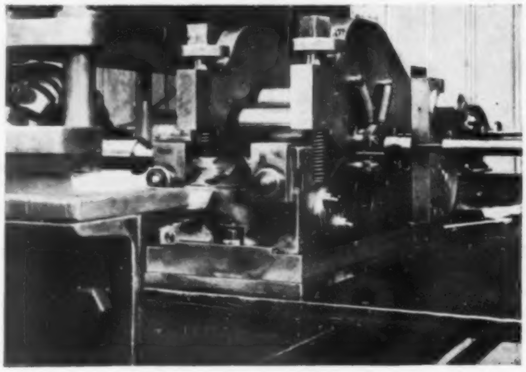

Fig. 6.—Twelve-roll mill with working rolls 10 mm. diameter.

In order to use still smaller rolls than is possible with six-high mills, owing to the limitation already referred to, the design shown in Figs. 5 and 6 has been developed. The support of the working rolls A in the rolling direction is provided in the same manner as in the six-roll mill, but since for the desired size of these working rolls the permissible diameter of the pairs of backing rolls B is insufficient to prevent bending, three additional rolls C are provided for the support of each pair. These rolls C can be made in accordance with Fig. 3, carried on fixed shafts with two roller bearings. The intermediate rolls B can be made without necks, but it is advisable to fit them with a light spindle carried at each end in a collar bearing which is lightly pressed against the rolls C by a spring. For rolling strip for tinplates or transformer sheets with rolls 300 mm. to 400 mm. long the working rolls are given a diameter of 30 mm. to 50 mm., this being doubled for the intermediate rolls, and again doubled for the outer supporting rolls. With these it is possible to use two to three times the reduction obtained with 80 mm. to 120 mm. diameter rolls, and accordingly to reduce the number of passes to one-third of what has been the practice hitherto. The rolling costs fall to a fraction, and the power consumption is considerably reduced.

With a roll diameter of 30 mm., and a rolling speed of 45 mm. to 50 mm. per min. (148 ft. to 165 ft. per min.) the working rolls run at 500 r.p.m. It is therefore possible to dispense with reduction gearing, driving each roll by a separate motor, one on each side of the mill. It appears possible to use this construction also for hot rolling sheets and strip from 30 mm. down to 2 mm. thick, but it is especially suited for economical cold rolling without intermediate annealing from 2 mm. down to final thicknesses of 0·1 mm. and less.

The extent to which the reduction in roll diameter can be carried is shown in a twelve-high mill, Fig. 6, with housings in accordance with Fig. 4. This has a roll length of 80 mm., the working rolls being 10 mm. diameter, and the supporting rolls 20 mm. and 40 mm. diameter respectively. With soft steel and nickel final thicknesses of 0·01 mm. can be obtained, the successive passes giving 0·5, 0·25, 0·01, 0·045, 0·025, 0·015, and 0·01 mm. thick. With copper the thickness can be reduced to 0·008 mm. Only two passes are thus required in reducing from 0·1 mm. to 0·025 mm. thick, instead of five with the six-roll mill having 25 mm. rolls, as already given. The power required for each of these passes is only 1 kw. for 40 mm. wide strip rolled at 10 mm. per min. Apart from the exceptionally low cost of these tiny rolls, the durability of them was quite exceptional. It was, further, a matter of surprise that with a Scleroscope hardness of 85 the durability was as good as that of the 25 mm. diameter rolls with a hardness of 95. Since the load which is to be taken by the housings is very little on account of the smallness of the diameter, the cost of the twelve-roll mill for any particular duty is only half that of a six-roll mill of the usual design, while, owing to the heavier reduction per pass the output is several times greater. A special point is that it is possible to produce the thinnest sheets without doubling, so that very thin but wide material can be made as endless strip instead of being rolled as individual sheets.

The innovations described above are protected by a number of British patents (Nos. 363,970, 354,234.)

Metals in the Service of the Printer.

THE above subject was discussed by Mr. A. H. Mundey, at a recent meeting of the Printing Crafts Guild, held at Manchester College of Technology. Describing the efforts of the early printers to produce type, he showed, with many graphic illustrations, the gradual evolution of the present-day alloys employed by the printer. Constituent metals—lead, tin, antimony, as well as copper, zinc, and aluminium—were briefly described. Reference was made to the efforts of the old-type caster to harden lead by tin and antimony, and his devices for the introduction of antimony by the reduction of antimony sulphide by iron in the presence of lead, proved of considerable interest.

The use of lead as the basic metal, with antimony to harden it and tin to toughen and refine the structure, was made clear, and the effect of impurities, of improper treatment in melting and in use, the methods of cleaning and fluxing, and the necessity for temperature control in working, were described. Mr. Mundey sought to make the underlying principles perfectly clear, so that any skilled manager or craftsman could appreciate the necessity for correct composition and treatment of the alloys in every phase of the printer's work.

The composition of the typical alloys used was given. Thus, for linotype or intertype and similar composing machines producing slugs, tin 3 to 5%, antimony 10 to 13%, the remainder being lead; monotype, tin 6 to 10%, antimony 15 to 19%, remainder lead; and stereotype, tin 6 to 10%, antimony 15 to 17%, remainder lead. Also special alloys for display type, founders' type, electro-backing metal, and other purposes.

The methods in use for melting metals, from the most primitive times to the most modern, were reviewed. Fuel and heating agents of all sorts, including coal, coke, all types of gas-firing, and finally electrical heating were considered. The modern Funditor heaters for electrically heating the metal in the linotype, intertype, and monotype machines, and also for remelting slugs, were emphasised. The advantages accompanying the application of electricity for these purposes; the perfect control and regularity of heating, the freedom from all fume and odour, and the consequent clean and comfortable atmosphere in the composing room proved of particular interest.

Fuel Oil in Metallurgical Melting and Heating Practice

By T. F. UNWIN

Factors which have led to the use of fuel oil are discussed. Proper oil furnaces, specially designed to obtain the advantages from fuel oil are stressed and consumption figures are given as a guide to its economy in use for a wide range of metallurgical operations.

IN the last few years the great strides made by metallurgists in the science of materials, and the ever-increasing exactitude required in the manufacture of the component parts of modern machinery, have made it essential for the various heating operations involved in the preparation of the alloys used and the production from them of component parts of machines in the most suitable form to ensure high working efficiency and long wear to be placed on a scientific basis.

The pressure of competition and the general demand for improved working conditions, also render it necessary that all such heating processes shall be carried out not only in a most exact manner, but at the lowest cost and with the least possible amount of dirt, smoke, and fumes. In order to meet these requirements, fuels, furnaces, and heating arrangements generally have in the last few years received close attention.

In this country the use of solid fuels was, up to a few years ago, almost universal, and the industrial furnaces employed were, in most cases, of antiquated design and very wasteful of fuel. A point of even greater importance, however, is the fact that the combustion conditions could not be accurately controlled, being dependent upon a variable fuel, the skill of the fireman, draft conditions, etc. The temperature and furnace atmosphere could not be relied upon, scaling losses were heavy, and the resulting products apt to be variable. Such conditions were clearly unsuited to the meticulously accurate methods in operation to-day, and recourse had to be made to better methods.

The chief requirements in a fuel for modern conditions are thus accurate controllability of combustion coupled with low B.th.u. cost. Table I. shows the cost of B.th.u.'s in various fuels, and it will be observed that the fuels having the greatest controllability factor are generally those in which the heat units are more expensive.

Liquid fuel or fuel oil, as it is commercially known, occupies an intermediate position as regards B.th.u. cost, but when its high controllability is taken into consideration, an immediate explanation is forthcoming of its rapidly increasing use where accurate heating at low cost is required.

Fuel oil is one of the many products obtained from the distillation of crude petroleum, and is now available in large quantities in every part of the country.

The Board of Trade required that fuel oil shall have a flash point over 150° F., and in practice a safe margin is allowed, the product normally marketed for industrial purposes having a flash point about 200° F.; it is not inflammable at ordinary temperatures, and will not burn in the liquid state.

It will be apparent that if controllable fuels, such as fuel oil, are to be widely employed, the most efficient use possible must be made of the heat units in them, and as it is now essential to have the accessory advantages of these fuels, furnace design has developed so as to increase the efficiency of transfer of heat from the products of combustion to the materials to be heated.

Until quite recently the technique of oil-furnace design had not received anything like the attention it deserved, but lately considerable developments have taken place, and, assisted by great improvements in oil-burners, oil furnaces are now available which can successfully carry out nearly all the processes commonly met with in industry.

The question of what fuel to use for a given heating operation is a difficult one, and the decision should rest on a close analysis of all the factors involved.

There has been a tendency to over-emphasise one or two items, such as primary B.th.u. cost, labour cost, etc., whilst leaving out of account altogether such essential features as the cost of the losses due to defective control of furnace atmosphere or the value of high production from a furnace of limited size. It is in most cases a difficult matter to assess accurately all the factors involved, but only by so doing can a true picture be obtained and a correct decision made.

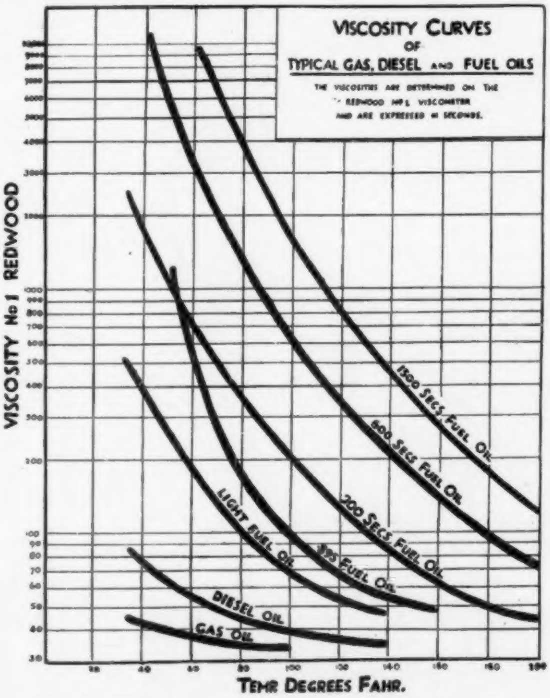

Fig. 1.—Viscosity curves for certain standard fuel oils.

The general advantages of fuel oil for furnace heating are as follows :—

High Controllability of the Fuel.—Liquid fuel can be burned in the exact quantities required for the heating operation to be carried out. The fuel can be mixed with the correct quantity of air required to give complete combustion, and an oxidising or reducing atmosphere in the furnace obtained. An oil-fired furnace can be automatically controlled as to temperature if desired. The conditions of combustion and of the furnace chamber are positively controlled, and are not subject to variations due to external causes.

Flame Control.—All shapes and sizes of flame can be produced with oil fuel, and in addition the flame can be made fierce or soft, reducing or oxidising. The radiative power, also, can be varied.

Simplicity.—The apparatus necessary to obtain the best results is simple and inexpensive, as is the control apparatus, which consists normally of two valves and secondary air control.

Standby Losses.—With fuel oil these are a minimum, as the flame can be started or stopped instantly, and the furnace reaches the working temperature very quickly. This point is of great importance where intermittent operations have to be carried out, loss of time being reduced to a minimum, and overhead charges decreased.

Residue from Combustion.—With proper apparatus and control, all fuel can be burnt completely to colourless gases. There is no smoke, no ashes or carbon deposit in the combustion chamber, nor deposits of dust or soot in the flues (Cf. the periodical cleaning-out of flues necessary in a furnace fired with producer gas).

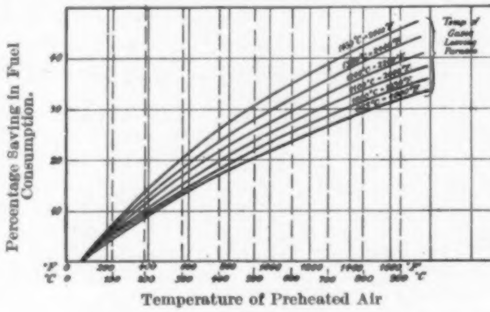

Fig. 2.—Saving in consumption of fuel oil in furnaces by preheating all the combustion air to various diameters.

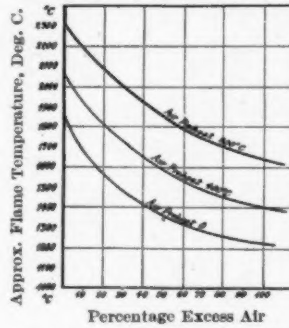

Fig. 4.—Relation of excess air to flame temperature.

Consistent Calorific Value of Fuel.—A given grade of fuel oil has always the same heat content per pound, and does not deteriorate in storage. Oils may vary in origin, viscosity, and composition, but are all of similar calorific value.

Convenience of Storage, Handling, etc.—Bulk for bulk, oil has a greater heat content than solid fuel, so that for a given output the space required for storage is only about three-fifths of what is necessary with solid fuel. In addition, oil tanks may be accommodated in convenient waste spaces, and need not occupy valuable ground space. The handling of oil from storage tanks to furnaces is much simpler than with solid fuel, especially where a large number of furnaces are distributed around an extensive works, the whole operation being easily carried out by means of power-driven pumps.

Cleanliness and Healthy Conditions in Shops.—Oil fuel is contained in closed tanks or pipes, so that it is never seen, and a complete absence of dirt can be guaranteed, to the great benefit of those working in the shops, whilst maintenance charges on moving machinery situated in the same shops as furnaces are reduced through absence of grit in bearings, etc.

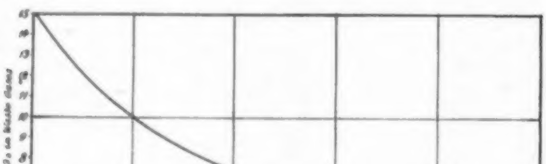

Fig. 3.—Relation of CO_2 content of flue gases to excess air.

Maintenance Costs.—Maintenance costs on burner equipment are negligible, whilst blowing units and motors are reliable and last lengthy periods. Supervision and lubrication charges for these are quite low. With regard to furnaces, any difficulties experienced with brickwork have been due to badly designed furnaces and poor or unsuitable burners. Troubles with brickwork when using fuel oil can be easily avoided when furnace and burners are properly designed in relation to one another, and suitable qualities or refractories employed.

Checks on Consumption and Fuel Used.—Oil is easily measured either in the tanks or with meters, and a close check can be kept on the consumption of each furnace or unit. To know definitely where waste occurs is to be able to stop it, and this is very easily accomplished where oil is used.

Continuous Operation.—No stoppages are necessary with oil-fired furnaces, the same temperature and output can be maintained for days, weeks, or months on end, as required.

Labour Costs.—Owing to the entire absence of handling and stoking charges and the exceedingly simple controls, labour charges are reduced to a minimum.

Space Economy.—Particularly in cases where direct heating is carried out and the high radiative power of an oil flame given full scope, very high outputs are possible with oil-fired furnaces of limited size, so that the production from a shop of given area and machinery of a certain size and cost is maintained at a maximum. This has an important effect on the lowering of overhead charges.

Operating Costs.—Actual B.th.u. costs with oil compare with town gas and electricity as follows:—A therm, or 100,000 B.th.u.'s in electricity at ½d. per unit costs 1s. 2½d.; in town gas at 2s. per 1,000 cub. ft. approx., 5d.; and in oil at normal prices rather below 2d.

It will be seen that fuel oil has all the essential features of a modern controllable fuel, but the great feature of liquid fuel is that the various advantages can be obtained at the lowest cost.

TABLE I.

THERMAL VALUE OF VARIOUS FUELS.

Fuel.	Calorific Value.	Cost per Therm (100,000 B.th.u.'s)	B.th.u.'s for 1d.	Calculated at
Electricity	3,413 B.th.u.'s per unit.	14·65d.	6,826	½d. per unit
Town Gas	500 B.th.u.'s per cub. ft.	4·8d.	20,833	2s. per 1,000 cub. ft.
Fuel Oil	19,000 B.th.u.'s per lb.	1·83d.	54,500	65s. per ton
Producer Gas .. (Small plants)	150 B.th.u.'s per cub. ft.	2d.	50,000	3d. per 1,000 cub. ft.
Producer Gas . (Large plants)	Ditto.	1·33d.	75,000	2d. per 1,000 cub. ft.
Coke-oven Gas.	500 B.th.u.'s per cub. ft.	1·8d.	55,500	9d. per 1,000 cub. ft.
Coke	11,000 B.th.u.'s per lb.	1·46d.	68,400	30s. per ton
Coal	13,500 B.th.u.'s per lb.	0·79d.	126,000	20s. per ton

It is not intended to give the reader the impression that fuel oil is the best fuel for every industrial heating operation, as, like other modern fuels, it has its own sphere.

For large-scale operations, such as those carried out in iron and steel works, for example, where vast quantities

of heat are required, it is clearly good practice to employ that fuel having the lowest B.th.u. cost, which is coal, or a close and cheap derivative such as blast-furnace, coke-oven, or producer gas ; for an operation such as the continuous heat-treatment of pen-nibs, obviously electric heating, in spite of high thermal cost, will be the only economical method of obtaining the localised heat required, whilst the heating of soldering irons and similar small jobs will be best accomplished with town gas. Between these extremes, however, are a large number of heating operations, for which in most cases oil fuel is particularly suitable.

The special province of fuel oil in industry may be stated as all those heating operations where accurate temperature and furnace atmosphere control, low cost and high output per unit are necessary, from a B.th.u. requirement of about 40 000 per hour, up to the point where the B.th.u. output is so large that the use of coal in some form or other, with its cheap B.th.u.'s, becomes essential from the fuel cost standpoint.

Much disappointment can be occasioned to users of liquid fuel, by the crude appliances sometimes employed for using it, and by the peculiar and rather widespread tendency to use fuel oil in furnaces designed for other fuels and hastily converted to oil-firing. If satisfactory and economical results are to be obtained with oil, proper oil furnaces, specially designed for that fuel, should be employed.

In oil furnaces the chief requirements for economy are :—

1. The use of thoroughly efficient burners, giving a suitable size, shape, and character of flame.
2. Simple and effective controls (automatic, if desired).
3. The utilisation of recuperative devices whenever possible to minimise the loss of heat in the waste products of combustion. Fig. 2 shows the saving in fuel to be obtained by this means.
4. Suitable high-quality refractories are essential in the region of the flame.
5. The output from each unit, particularly in the case of reheating furnaces, should be as high as possible.
6. Insulation should be suitably disposed to prevent excessive radiation loss.
7. The amount of excess air passing through the furnace should be reduced to a minimum.

When setting an oil furnace to work, the condition of combustion should be determined whenever possible by means of a CO_2 recorder, and a figure of not less than 12% should be obtained. Fig. 3 shows the relation between CO_2 content of waste gases and excess air, and Fig. 4 the lowering effect of excess air on the flame temperature.

There are several grades of fuel oil available to suit various requirements, these being usually specified by their viscosity, which in this country is measured at 100° F. on a Redwood instrument. Fig. 1 shows the viscosity curves of certain standard fuel oils.

In this connection a most important feature of all petroleum fuel oils, which must always be taken into account in their handling and use, is that the viscosity increases with the fall in temperature, wherefore the process of atomisation is greatly facilitated if the oil is supplied to the burner reasonably warmed. For this reason it is usual to provide for heating of the oil either in the storage tanks or on its way to the furnaces, so that a uniform temperature may be obtained. The optimum temperature varies according to the grade of oil employed, and some of the lower viscosity oils can be burned cold.

It will be clear that as fuel oil is not inflammable in the liquid state, in order to produce a flame means have to be provided of splitting it up into finely divided particles and of mixing it with the requisite quantity of air for efficient combustion in the furnace. This is the function of oil burners, of which a very large number of various types is available.

The breaking up of the oil by the oil-burner requires some form of energy, and burners utilise any of the following agents for atomisation purposes :—Low-pressure air ; medium-pressure air ; high-pressure air ; steam ; pressure on the oil itself.

As far as industrial furnaces are concerned, steam-jet and pressure-jet burners are hardly ever used, the various air-atomisation burners being almost universally employed, and these may be broadly classified as follows :—

Low-pressure air burners are those employing air supplied by a fan at pressures up to about 28 in. water gauge ; medium-pressure air burners operate with air at a pressure of 1 lb. to 5 lb. (usually 2 lb. to 3 lb.) per sq. in., supplied by a positive blower ; while high-pressure burners include all those requiring a compressor for providing the air, and run at pressures of about 10 lb. per sq. in. and upwards.

With the greater energy in medium-pressure air, a lower percentage of the total combustion air is necessary for atomising than with L.P. air, good results being possible on less than 5%, or about 10 cub. ft. free air per pound of oil atomised. In addition, smaller flames can be obtained, using down to 2 lb. or 3 lb. of oil per hour. For these reasons medium-pressure burners are generally used in modern practice, in the following conditions :—

1. Where small flames using under 1 gal. of oil per hour are required.
2. In all recuperative and regenerative furnaces where air is preheated to over 200° C.
3. Where short flames are required to conform to a limited combustion space.
4. Where fuel oils of comparatively high viscosity are to be used and oil-heating facilities are deficient.

High-pressure burners using compressors are usually to be found on regenerative furnaces, such as glass tanks, where the absolute minimum quantity of cold air must be used for atomisation. They are also used in portable burner plants, where no assistance in vaporising the oil can be obtained from a hot combustion chamber, burner block, etc.

It is impossible in a short article such as this to mention all the multitudinous purposes for which fuel oil is now used in British industry, but a general indication of the heating operations for which this fuel is now being found to be pre-eminently suitable is given hereunder :—

Reheating of steel bars or pins for stampings, forgings, bolts, nuts, etc.
Rivet heating.
Tube and conduit welding and annealing.
Melting of aluminium and copper alloys in either reverberatory or crucible furnaces.
Annealing of copper tubes, brass strip, etc.
Melting and superheating of special irons, in quantities up to 2 tons per charge.
Heat-treatment of steel parts, including carburising, normalising, high-speed steel, etc.
Drying of lacquered and enamelled tinplate and sheet-iron articles of every description.
Vitreous enamelling and enamel smelting.
In shipyards, plate and bar furnaces and rivet heating.
Sheet galvanising baths, tin pots, etc.
Lead melting and refining, etc.

An approximate figure for the consumption of fuel oil for certain standardised processes in common use are given hereunder ; all are stated on a percentage weight basis—*i.e.*, pounds of oil per 100 lb. of metal treated. They should be treated as a rough guide only, variations being frequent in practice, depending upon local conditions :—

1. Melting high copper alloys :	
Reverberatory furnaces	6 to 8%
Crucible furnaces	8 to 10%
2. Melting high-duty irons, ½ to 2-ton lots pouring at about 1,600° C.	16 to 18%
3. Annealing brass strip at 650° C.	1·5%
4. Heating copper billets to 900° C. for extruding	1·8%
5. Lead melting	0·5%
6. Sheet galvanizing	1·2%
7. Forging, stamping, etc.	12 to 10%
8. Copper wire annealing	2·7 to 3%

SELENIUM AS AN ALLOY IN RUSTLESS STEEL.

A NEW rustless steel which contains selenium has been developed by the Carpenter Steel Co., Reading, Pa. The outstanding effect of the addition of selenium to such steels is to render them free-cutting, the new metal replacing sulphur, according to the company. It is also claimed that selenium has proved equal to sulphur as a free-cutting agent, and that at the same time it avoids some of the objections to high sulphur content.

Selenium is a by-product of copper smelting and the manufacture of sulphuric acid. Early experimental work by the Carpenter Steel Co. was done with elemental selenium, but the losses in adding to the molten metal steel bath led to the adoption of an alloy of iron and selenium developed especially by the American Smelting and Refining Co. A typical analysis of this ferro-selenium is: Selenium, 52·11; iron, 41·42; C, 9; Si, 0·72; P, 0·2; S, . 32. The ferro-alloy is heavier than pure selenium, and is more readily assimilated by the steel bath.

Selenium Replaces Sulphur.

The first commercial use of selenium steel has been in a free-machining 18–8 rustless steel, known as Carpenter stainless steel No. 8. This is an austenitic steel containing approximately 18% chromium, 9% nickel, and 0·25% selenium. When this brand of free-machining 18–8 was first announced by the Carpenter Co. a few months ago it contained about 0·30% sulphur as a free-cutting agent. The sulphur has now been replaced by selenium.

The new free-cutting No. 8 analysis is melted in high-frequency induction furnaces. The steel-making progresses as usual until a few minutes before the heat is ready to pour, when a carefully weighed proportion of ferro-selenium is added on the surface of the metal and is swiftly carried down by the violent motion of the bath. The casting, hammering, rolling, and annealing proceed just the same as any other 18–8 steel. The finished product is so freely machinable that it can be automatic-screw-machined at 60 to 70% of the speed of Bessemer screw stock. It can be drilled, tapped, threaded, and otherwise machined with ordinary machine-shop tools and practice.

Some Advantages Claimed.

Selenium has several distinct advantages over sulphur as a free-cutting agent. Some of these and others are pointed out by the company as follows: Tensile and impact tests made transverse to the direction of rolling on free-machining 18–8 steel furnish an interesting comparison between the effect of sulphur and selenium as free-machining agents. Holding all other conditions equal, the selenium steels have about one-third greater elongation and reduction of area and twice the Izod impact resistance. The ultimate strength is the same. The greater transverse toughness of 18–8 containing selenium reflects in several ways upon the fabrication and use of the product. The selenium steel is easier to roll and forge than the sulphur types, being less subject to splitting, cracking, or opening up at the ends. The selenium steel can be upset with greater safety and less trouble from splitting. High sulphur 18–8 is utterly useless in the form of sheets or strips because it will stand practically no longitudinal bending and no deep drawing. The selenium steel will do both, although not so well as 18–8 steel, without sulphur or selenium.

From a corrosion-resisting standpoint selenium also has some advantages. It does not impair in any way the resistance to the salt-spray test, and it does increase the resistance of the steel to certain chemical solvents, such as boiling solutions of acetic acid and aluminium sulphate.

Physical Properties at High Temperature.

The extended use of 18–8 steels for high-temperature service naturally leads to the question as to what effect selenium will have on strength at these high heats. It is obviously desirable to use a free-machining grade if possible in bolts, nuts, castings, and other parts that must be machined during the process of manufacture. The table gives comparative short-time tensile figures for regular 18–8, and free-machining selenium 18–8 up to 1,000° F. The elastic limit shown is the true proportional limit determined with an accurate extensometer. These figures show that selenium has, if anything, a very slight beneficial effect on the tensile strength at elevated temperatures. The elongation and reduction of area are appreciably lowered by the use of selenium, but are still amply high to ensure great toughness.

Metallography of Selenium Steels.

If the extent and distribution of non-metallic stringers is the correct explanation of the greater transverse toughness of selenium stainless steel compared to high sulphur rustless, we would expect to find confirmation of this under the microscope. That this confirmation is not lacking is shown by the accompanying photomicrographs. Both the etched and unetched sections show that the selenium steel not only contains less non-metallic matter, but the stringers are shorter and therefore interfere to a smaller extent with the continuity of the metal in a transverse direction.

TABLE OF EFFECT OF SELENIUM ON PHYSICAL PROPERTIES.

Analysis.	C.	Mn.	Si.	Cr.	Ni.	Se.
Stainless No. 4	0·11	0·29	0·20	17·91	8·06	—
Stainless No. 8	0·08	0·30	0·48	17·65	8·45	0·23

Temperature of Test.	Steel No.	Elastic Limit.	Tensile Strength.	Elongation in 2 in.	Reduction of Area.
70° F.	4	55,000	116,500	42·2	64·2
	8	52,500	112,000	41·6	65·0
800° F.	4	38,750	80,500	42·8	64·4
	8	39,250	83,800	27·4	61·9
900° F.	4	35,500	75,500	41·0	64·8
	8	36,500	80,400	24·5	46·6
1000° F.	4	32,500	71,000	37·3	65·1
	8	31,500	74,300	21·0	57·4

Typical etched structures are shown, and it will be observed that both steels show a pure austenitic structure and that the grain size is quite similar. The absence of twinning in the selenium steel is probably explained by the etching reagent used. A satisfactory etching reagent for standard 18–8 or the same grade containing high sulphur is made up as follows: 30 cc. HCl 10 cc. HNO_3 40 cc. glycerine. This is the etching agent that was used on the high sulphur steel samples shown, and brings out not only the grain boundaries, but twinning as well. This reagent will not satisfactorily etch selenium steel. It produces a black deposit on the surface of the steel which completely obscures the structure. This may be due to metallic selenium or some compound of selenium, although there is no confirmation of this. Strangely enough, if the selenium steel has been previously cold-worked the aqua-regia glycerine reagent will etch it fairly satisfactorily, and will reveal twinning. For selenium steel which has not been cold worked, it was necessary to develop a new etching reagent and the following mixture has been arrived at: 10 cc. phosphoric acid, 5 cc. HNO_3, 5 HF (42%), 100 H_2O. This reagent was used to etch the selenium steel shown. It has been observed that this HF reagent does not develop twinning even on an 18–8 steel free from selenium, and therefore the absence of twinning in the photograph is probably due to the etching reagent rather than to its absence in the steel. A patent, U.S. No. 1, 846,100, Feb. 23, 1932, covering the use of selenium in such steels has been granted to Frank R. Palmer, assistant to the president of the Carpenter organisation, and it has been assigned to the company.*

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200 new oil wells have been discovered in Ural Embra, where only one was believed to exist. Oil fields have also been discovered in addition to those known in Sakhalin, Baikal, and Kamaschatka.

* *Iron Age*, pp. 404–5, September 15, 1932.

Steels for Casehardening

By FRANCIS W. ROWE, B.Sc., M.I.M.M.

Free-cutting casehardening steels and nickel casehardening steels, together with the essential differences between carbon and nickel steels, were discussed in the last issue; in this, the factors that influence the physical properties of various alloy casehardening steels are considered.

3½% Nickel-Chromium Casehardening Steel.

WHERE the straight 3 or 3½% nickel steel has insufficiently high core strength, the next higher tensile grade more suitable is the 3½% nickel-chromium steel, preferably with about 0·20% molybdenum. The advantages of this particular class of steel are that it possesses a higher core strength—55/65 tons per square inch,—and the case has a slightly higher surface hardness. For heavy sections, also, the addition of chromium and molybdenum reduces the mass effect—that is, deeper hardening in large sections is possible.

Thus, it is possible with similar depths of case to carry higher surface loads without danger of the case collapsing. Furthermore, the uncarburised portions of any part after normal heat-treatment (finishing with an oil or water quench) are still capable of being machined. It has the highest core strength possible consistent with reasonably economical machining after standard treatment. This enables higher torque stresses and bending stresses to be carried in the hardened but uncarburised parts than the 3 or 3½% nickel casehardening steels. Also, for equal surface stresses, the 3½% nickel-chromium-molybdenum needs a lighter case (owing to the higher core strength) than the 3½% nickel, and this often results in material economies, particularly where it is desirable to use a single quench after carburising, as the danger of excess cementite is less with a shallower case.

It should be borne in mind, however, that the nickel-chromium steels are more prone to over-carburisation than the straight nickel steels, and allowance has to be made for this in carburising practice. This particularly applies to the 4·0% nickel, 1% chromium steels described later.

The usual chemical composition employed for the 3½% nickel-chrome steel is 0·13–0·17% carbon, 3·0 to 3·5% nickel, 0·50–1·0% chromium, and about 0·20% molybdenum. It is best made in the electric furnace, but with care can be made on an acid bottom in the open-hearth furnace. Due to the presence of so much chromium it is usually found advisable to rough turn the steel, either in the ingot form or at some stage of the rolling to remove the surface cracks more or less inevitable in ingots of this material. The chromium content also renders the steel rather more susceptible to abusive treatment in forging and stamping, but not so much so as the same class of steel with higher carbon contents. The surface hardness in the unground condition after hardening should reach Rockwell C 68 (Scleroscope 91) after water or brine quenching, and Rockwell C 66 (Scleroscope 88) after oil quenching.

Fig. 4—Cementite needles in corner of over-carburised piece in high-nickel-chrome-molybdenum casehardening steel. Magnification, 100 diameters.

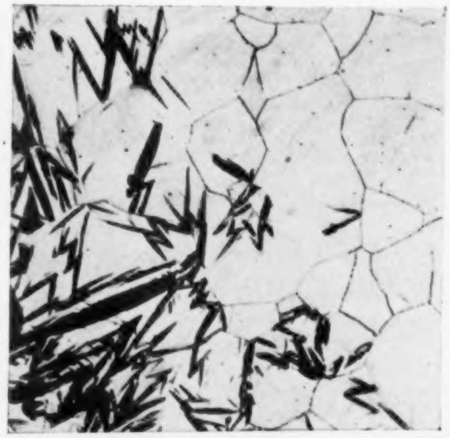


Fig. 5—Similar to Fig. 4, but in the quenched condition. Magnification, 500 diameters. Showing typical polyhedral austenitic grains with martensite.

4% Nickel 1·0% Chrome Casehardening Steels.

This class of casehardening steel with core strength up to 90 tons per square inch is gaining tremendously in popularity, particularly for automobile and aero engine work. The composition is now fairly well standardised by the different makers, and falls within the limits called for by Airboard Specification D.T.D. 121. The carbon content is usually about 0·15%, with 4·0% nickel, 1·2% chromium, and 0·2% of molybdenum. Water-quenched from 780° C. it has a core strength from 85 to 95 tons per square inch, dependent on the section, and oil-quenched from 75 to 85 tons per square inch, varying from the same cause. This steel is nowadays the first choice by leading gear and automobile manufacturers for such arduous duties as gearbox gears, heavily stressed differential gears, and the like. Its very high core strength allows of quite light cases supporting tremendous surface loads without pitting or collapse, and the high surface hardness gives great resistance to abrasive wear. It is seldom necessary, or indeed advisable, to use case depths greater than 0·050 in. with this class of steel, and for most work 0·035 in, is sufficient.

As previously mentioned, it is much more susceptible than the straight carbon or nickel steels to over-carburisation, and care should be taken to work with the lower carburising temperatures, 860°–880° C. Freckled edge (causing extreme brittleness if unremoved) is easily obtainable with case depths of 0·040 in. to 0·050 in., with carburising temperatures of 900° C. and above. Fig. 4 shows a typical micrograph of cementitic needles in the corner of a piece carburised in this way. Fig. 4 shows the typical austenitic martensitic structure obtained after quenching one of these over-carburised corners—polyhedral grains of pure austenite where the carbon is highest near the extreme corner merging to the mixed structure showing well-defined martensite "feathers" as the carbon drops.

Provided suitable precautions are taken to avoid these structures, this steel presents no difficulties, and has solved

many problems connected with heavily loaded case-hardened parts.

5% Nickel Casehardening Steels.

The 5% nickel casehardening steel is apparently losing ground with the rise in popularity of the 3½% nickel-chromium, and the 4% nickel, 1% chromium steels. Whilst definitely a reliable and valuable steel, it has a somewhat low core strength in heavy sections when made to the usual specifications extant in this country, and has a lower maximum surface hardness than any of the steels previously mentioned. Table II. shows the relative maximum hardness figures obtainable with the various types of case-hardening steels.

The usual B.S. and Airboard specifications call for a carbon content of 0·10 to 0·15%, with manganese 0·25%,

TABLE II.

MAXIMUM SURFACE HARDNESS.

MAXIMUM SURFACE HARDNESS FIGURES FOR CASEHARDENED PARTS IN VARIOUS STEELS.

These figures are naturally reduced when quenching conditions due to mass or shape of the part cannot be made ideal.

—	Oil Quench.		Water or Brine Quench	
	Rockwell.	Scleroscope.	Rockwell.	Scleroscope.
0·15% carbon	C58	77	C68	91
3½% nickel	C64	85	C66	88
5% nickel	C62	82	C64	85
3½% Ni, 0·7% Cr., 0·20% Mo.	C65	86·5	C67	89
4% Ni., 1·2% Cr., 0·20% Mo.	C66	88	C68	91

and nickel 5·0%, consequently this steel when oil-quenched has a core strength of less than 55 tons in medium and heavy sections. Drastic quenching also is needed to secure a surface hardness of C 64 Rockwell.

It would seem, therefore, that this steel hardly meets present-day ideas of the necessary requirements as well as the 3½% nickel-chromium and the 4% nickel 1·0% chromium steels, both with molybdenum.

Other Casehardening Steels.

Whilst the above steels comprise all those of which there is any large consumption in this country, it would be well to touch upon one or two other casehardening steels which enjoy no small reputation elsewhere, and could perhaps be deservedly employed for certain duties in this country. One of these is the SAE steel 6130, a 1·5% nickel, 0·30% molybdenum steel having from 0·16% to 0·20% of carbon. Due to its lower nickel content, it is slightly cheaper than the 3 or 3½% nickel steels and machines rather more freely, due probably to the higher carbon content and the presence of molybdenum.

Its physical properties and general treatment are similar to those obtaining with the 3½% nickel steel, and, if anything, a slightly higher maximum surface hardness is obtainable. It is, however, rather more sensitive to errors in heat-treatment than the 3½% nickel, though this should be no serious disadvantage in a well-controlled modern hardening shop.

The chromium vanadium casehardening steels are also very popular in the States, but here again close investigation would appear to favour the nickel, nickel-chromium and nickel-chromium-molybdenum steels popular in Europe.

Making Chromium Additions to Cast Iron

CONSIDERABLE difficulty is generally experienced in adding chromium to cupola mixtures, and unless reasonable care is exercised in adopting a tried method heavy loss is likely to occur. Some interesting results, taken from records of experimental work on various methods of making chromium additions to cupola-melted cast irons, are given in a recent issue of *Bradley's Magazine*, which indicate how much the method may influence the loss of chromium. The experiments were carried out in a cupola equipped with a receiver. The mixtures were charged in 5-cwt. units, and the receiver contained at least four unit charges before samples of the molten metal were taken for analysis. In each case the experimental mixtures were made up from materials specially analysed and carefully calculated.

In the first experiment, addition of chromium was made by means of 50% ferro-chromium, which was added to the cupola mixture. The method adopted was the addition to the mixture of the ferro-chromium in the form of lumps of approximately large walnut size, and thrown in amongst the charge by hand in such a manner as to dispose the alloy throughout the whole charge. This method resulted in an excessive loss of chromium from a calculated percentage in the final metal of 0·51 to 0·09, the actual percentage in the final metal, equivalent to over 80% of the ferro-chromium addition.

This experiment was repeated, but slightly smaller ferro-chromium was used, it being added in a similar manner. This method also resulted in excessive loss, equivalent to over 70% of the ferro-chromium addition.

The third experiment was carried out with the object of finding out the loss of chromium, if any, when remelting scrap heads, risers, and castings of chromium iron. The loss in chromium content, taken on the mean value, from a number of tests amounted to 0·006% chromium, which was equal to a loss of 5% of the original mean chromium content of the metal.

A refined alloy pig iron, containing 2·75 to 3·0% chromium, was used to make the chromium addition in the fourth experiment. In making the charge, a calculated percentage addition of 0·44% chromium was made, and the final metal on analysis contained 0·386% chromium, giving a loss of approximately 12·25% on the calculated chromium content. This method was repeated in the fifth experiment, but in addition to charging refined chromium pig iron, containing 2·75 to 3·0%, chromium scrap from previous mixture containing approximately 0·25 to 0·5% chromium was also charged. In this case, the loss in chromium content amounted to approximately 4·75% of the calculated chromium content.

A sixth experiment was made, using a refined chromium alloy pig iron containing 8% chromium, and the loss was found to be reduced to approximately 2·5% of the calculated chromium content.

In presenting these results, the author appreciates that the conditions existing in a particular cupola plant considerably influence their character and magnitude. In other plants and under other conditions, the results obtained may vary greatly, but these particular results are of comparative value in that they show the variations in yield of chromium in the final metal when additions are made in various forms under approximately constant general conditions, and they demonstrate the improved yield due to the additions of chromium in a diluted form either in the scrap or as alloy pig irons.

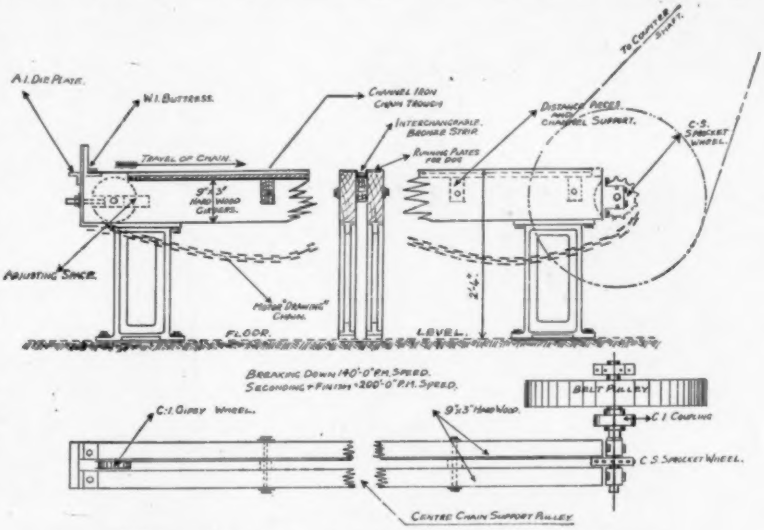
The development of alloy cast irons has resulted from the desire to meet more adequately the exacting conditions of service now imposed upon certain types of castings. Much research and experimental work has been necessary to obtain a precise understanding of the behaviour of alloy irons under the variety of conditions which they are called upon to withstand in their practical application. The increased knowledge obtained is having a considerable influence on engineers and designers, and there can be no doubt that the future trend of machine design will rely more and more on the specific properties of alloy cast irons.

Converting the Scrap of a Non-Ferrous Tube Mill into Valuable Stock

By Gilbert Evans.

An effective method of dealing with scrap ends of non-ferrous tubes that has a considerable economic value. The construction of a high-speed bench, for drawing-in tube cuttings, is described.

THE scrap ends of non-ferrous tubes, such as condenser tubes and the like, differ from the crop ends of similar steel material, inasmuch as the former are capable of being remelted when a small percentage is mixed with the other constituents in succeeding casts, whereas the steel ends are purely and simply scrap, and as such are consigned to the general scrap heap. The object of this article is to draw attention to utilisation of ends of suitable lengths, such as are left over in the final cutting of condenser tubes to dead lengths, for further drawing-in to small diameter and thin walls to meet requirements of radiator tubes for motor-car engines, optical tubes, lubricating connections, and similar purposes. This can be accomplished at small initial outlay in the shape of a battery of high-speed benches, constructed as shown in accompanying working sketch, and consisting in the main of suitable countershaft with pulleys arranged in ratio to the required chain speed of the various benches. The body or table consists of two hardwood 9 in. × 3 in. planks, with distance-pieces between, bolted together at intervals. Arranged on top end, between the planks and resting on the distance-pieces, is a steel channel iron, about $2\frac{1}{4}$ in. inside × $1\frac{1}{4}$ in. sides, to which is fastened a bronze strip with countersunk head-studs, the whole forming the chain race. Thin strips of steel are let in the top of each plant to form a plate on which the draw-dog traverses. The chains used are of motor type, supplied by Hans Renold and Coventry Chain Co., the pitch of which are $1\frac{1}{4}$ in. and 1 in. standard. To operate the chains, sprocket-wheels of standard diameters and pitches are obtainable from the same manufacturers. Ordinary bearings support the sprocket-wheel and pulley-shaft at the driving end, and these are secured to the planks by suitable means. At the die-plate or working end of the benches two pieces of flat steel formed into buttresses, to support the die and take the pull exerted in the drawing operation, are fixed, while a shrouded pulley or shaft is arranged with lateral adjustment for taking up slack of chain. Angle-iron bolted across the buttresses makes a suitable die-table, to which may be added a tin or sheet-iron tray to contain the lubricating material. The whole bench may be supported on old lathe stands or supports generally found among the miscellaneous scrap of a factory, or alternatively may be constructed of wood. The bronze running strip attached to the bottom of channel forming the chain race is to support the rollers of the chain, and keep the bottoms of the side-links from actual wearing contact with the channel itself. Suitable speeds for the chains may be set at 140 ft. per min. for breaking down, and 200 ft. per min. for finishing. No special arrangements need be made for the pickling and annealing between the drawing processes, as tubes of such small dimensions may be either bundled together or coiled and worked in with these treatments with the ordinary work of the main tube mill. The other auxiliary tools need consist only of an ordinary small smith's anvil and hand hammer, and one or two circular saws, with blades of small diameter and thin gauge. The draw-dog is of accepted design, arranged with loose bits for bar-drawing, and of scissors type for sinking and finishing. A small frame, with rollers arranged behind the die, is used in bar-drawing to release the tube from the drawing-bar. In manufacturing very small diameters, the tubes are drawn in bars to a slightly thinner gauge than is ultimately required, and afterwards sunk through dies to the required finished diameter ; this allows for slight thickening in the shell, as is usual in the sinking process. As an example, the ends of condenser tubes, $\frac{3}{4}$ in. × 16 I.W.G., or $\frac{5}{8}$ in. × 18 I.W.G., may be drawn in to commercial lengths of $\frac{1}{4}$ in. × 26 to 28 I.W.G. by a series of five or six passes. It is necessary process to give sufficient sink in diameter, and reduction in wall thickness, to obviate the serious defect of fire cracking. Benches as described can be made ready for work, and of lengths of 18 ft. to 26 ft. for an outlay estimated at £20 to £30 per bench. Apart from increasing the value of scrap to that of saleable goods, there are numerous channels for the disposal of small tubes, a branch which many makers refuse to be bothered with, the ability to supply, however, often leads to orders being secured for larger diameter tubes, to ensure completeness of supply from one source.



High-speed chain benches for radiator, optical and other small tubes.

Metal Sections, Ltd., Bordesley Green Road, Birmingham, have issued a revised catalogue of light sections they produce in standard shapes from bright mild-steel strip. There are numerous shapes given which cover a wide field of application. This firm also supply metal sections in hot-rolled, hot-rolled and pickled, lead-coated, tinned, and electro-galvanised mild steel, stainless steel, non-ferrous metals, and alloys, and also brass-covered steel. This apparently is new industry in this country, and prospective users of light sections should obtain a copy of this catalogue.

Reviews of Current Literature.

Flotation Plant Practice.

THE recovery of valuable minerals from certain classes of ores by means of the flotation process is one of the commonest methods. In the early application of the process, which was confined to sulphides, oil was introduced into a vessel containing ore and water, and air was introduced into the mixture by various means to create violent movement. The particles of sulphide mineral were coated with oil, and to this oil film bubbles of air attached themselves, causing the particles to float to the surface where they were collected as a froth and were skimmed off. Further research has established the effectiveness of various organic reagents other than oil, while other addition agents are valuable under special conditions. By careful control of the process other minerals besides sulphides are now being successfully floated. Opinions differ regarding the fundamental basis of the flotation phenomena, the causes being variously suggested as chemical, physical, and some believe electrostatic. Originally nearly all the sulphides were recovered in one concentration, but development has been such that at present a variety of reagents is being used which make differential flotation possible, and the effect on the subsequent operations has been remarkable. So much progress has been made that the general procedure for the flotation of many classes of ores has become to a large degree standardised, and this book should prove a valuable asset to those who desire a general knowledge of the subject. Some lectures delivered by the author, Mr. Rabone, on modern flotation practice, which were designed to give the engineer and student a broad conception of the practice, excluding detailed information and theory where possible without affecting the purpose in view, created a demand on the part of some engineers engaged in metalliferous mining and metallurgical work for a book covering the same ground, but also containing such cost and capacity figures as might be useful to them in the preliminary calculations which they are often called upon to make in the field.

This book has been prepared with this object, and although it embraces only 141 pages, it is full of information that is directly applicable to modern practice of the flotation process. Care has been exercised in excluding other than modern machinery and methods of crushing and grinding the ore, while considerable attention has been given to the flotation reagents used. The principal flotation machines are described, and comprise mechanically agitated, air-lift or matless, and pneumatic machines; while various methods of flotation are discussed with special reference to several types of ores. The last chapter deals with the concentrate and tailing disposal, and the various machines involved are described. A useful index is added, and the book is well illustrated.

By PHILIP RABONE. Published by Mining Publications, Ltd., 724, Salisbury House, London, E.C. 2. Price 10s. 6d.

A.S.T.M. Tentative Standards, 1932 Edition.

EACH year the American Society for Testing Materials publish a book which includes all the tentative or proposed standards in effect at the time of publication. These proposed standards are published for one or two years, to elicit comments and criticism, of which cognisance is taken before being formally adopted and issued as an A.S.T.M. standard, although they are in wide use, due to their careful promulgation. This edition includes 226 proposed standard specifications, test methods, definitions of terms of recommended practice effective on October 31, 1932, of which 47 were accepted for publication for the first time.

New tentative specifications for ferrous materials cover lap-welded and seamless steel, and lap-welded iron boiler tubes, riveted steel and wrought-iron pipe, electric-fusion-welded steel pipe, cast-iron culvert pipe, structural rivet steel, structural medium steel, and the following kinds of zinc-coated (galvanised) wire and wire products: Telephone and telegraph wire, tie wires, farm-field and railroad right-of-way fencing, chain-link fence fabric galvanised after weaving, barb wire, and wire strand (cable). There are also given new tentative specifications for ferro-tungsten, low-carbon ferro-molybdenum, and molybdenum salts and compounds. Tentative methods of test for magnetic properties of iron and steel are included, as well as a recommended practice for safeguarding against embrittlement of hot-galvanised structural steel products and procedure for detecting embrittlement. New specifications for non-ferrous products cover hard-drawn copper transmission cable, copper water tube, aluminium-copper-magnesium-manganese alloy bars, rods and shapes, and magnesium-base alloy sheet and wrought shapes.

Proposed specifications are included for structural materials, coal and coke, preservative coatings, and insulating materials. A facsimile of the viscosity-temperature chart for liquid petroleum products appears (approved this year as a tentative standard). There are the new tentative methods of chemical analysis of calcium chloride—also the volume and specific gravity correction tables for creosote and coal tar. In addition, the book contains a comprehensive subject index and a complete table of contents which lists, under the general class of materials covered, all of the tentative standards pertaining thereto. This publication, comprising 1,236 pages, bound in blue cloth, can be obtained from the Headquarters of the Society, 1,315, Spruce Street, Philadelphia, at $8.00 per copy. Copies in heavy paper binding are available at $7.00.

The Alloys of Iron and Molybdenum.

THIS first volume in the monograph series is now published. It was written by J. L. Gregg, Metallurgist at Battelle Memorial Institute, and was critically reviewed before publication by numerous specialists. It offers to the metallurgist, engineer, steelmaker, or foundryman interested in alloy steels and cast irons, and to the scientist working on alloy systems, a complete critical appraisal of the literature and other sources of information on the alloys of iron and molybdenum, and on molybdenum in steel and cast iron.

To prepare this book the technical literature of the world was searched, and all important data were critically examined and correlated. The result is the first comprehensive review of the function of a single alloying element in the iron and steel industry.

The author discusses molybdenum minerals and ores, the alloy systems, and the manufacture and working of molybdenum steel. Several chapters are devoted to the properties and uses of alloy steels containing molybdenum. There is a complete review of the effect of molybdenum in high-speed steel, in nitriding steel, and in cast iron. The bibliography contains 515 references. This book puts at the disposal of the reader all of the information on molybdenum in its relation to the iron and steel industry, information now scattered through volumes of journals and text-books in many languages. It assembles all data of importance, and ensures that nothing pertinent will be missed. It avoids the time-consuming task of searching through bibliographies, and it collects in one volume critical summaries of the literature now available in the original only in a few of the larger libraries of the world.

It should prove invaluable to the practical metallurgist, steelworker, foundryman, and engineer, who will find in this book all essential data on molybdenum steel, complex alloy steel containing molybdenum, molybdenum high-speed steel, molybdenum in nitriding steel, and molybdenum cast iron. Most of these data are presented in readily usable charts and tables. The scientist and researcher, too, will have a correlated résumé of all important previous investigations on the simple and complex alloys of iron and molybdenum, a valuable basis from which to start his programme of research.

Published by McGraw-Hill Book Co. Inc., 330, West 42nd Street, New York, U.S.A. Orders received before January 31, 1933, will be charged $5.00, after which the price will be $6.00.

Electrodeposition of Nickel and Chromium*

By J. W. Cuthbertson, M.Sc.

Solutions used in nickel-plating are considered in this article; the effect of temperature, aeration, and agitation on the deposit discussed, and the need for care in the preparation of the work emphasised.

MANY solutions have been suggested from time to time, and they differ widely in their chemical compositions. The older method of nickel-plating, using the still vat, was invariably done from a double-salt solution—that is, nickel-ammonium-sulphate. This is severely limited by the solubility of the salt, and the metal ion concentration and low electrical conductivity. The type of solution with which we are concerned will, therefore, be the single-salt (nickel sulphate) bath, with addition agents.

Generally speaking, the more simple the bath the more satisfactory will it be. A complex vat may work very well at first, but it will fall off later, due to lack of proper control of the various reagents present. The solution should be under control as regards all or most of its constituents.

A nickel-plating solution is made up as follows :—

(*a*) Nickel salt to provide the nickel ions.
(*b*) A buffer substance, usually a weak acid.
(*c*) Material to facilitate anode corrosion.
(*d*) Material to increase electrical conductivity.

(*c*) and (*d*) are not so important as (*a*) and (*b*).

The buffer substance, which is always required to keep the bath working consistently, is either boric, citric, or tartaric acid. Chlorides are sometimes used to help the anodes to dissolve readily, those of nickel, ammonium, potassium, and sodium being common. Sometimes aluminium salts are added with the idea of increasing the conductivity, but it is doubtful if much advantage is gained.

Below are given the compositions of some of the solutions used by the author :—

No.	$NiSO_4$.	NaCl.	NH_4Cl.	H_3BO_3.	NaF.	H_2O.
	Lb.	Oz.	Oz.	Oz.	Oz.	Gal.
1	3	½	—	1	—	1
2	1	—	2	2	—	1
3	2	—	2	2	—	1
4	2	—	2	4	—	1
5	2	—	—	4	1	1

Sodium fluoride is being used quite extensively at the present time. It has a distinct effect upon the hardness of the nickel deposit.

Of the above solutions, the first two may be worked cold, and the remaining three heated to 35° C. Good deposits have been obtained in each case, although the first solution gave possibly the best results. Suitable current densities are as follows:—

Solution.	Current Density. Amps./Sq. Ft.
1	5–10
2	8–10
3	3– 5
4	15
5	10–30

The solution No. 4 has also been used at a higher temperature (54° C.), when it was found possible to increase the speed of working considerably. The maximum current density was 40 amps./sq. ft., which is lower than has been claimed by other workers using baths of similar composition. Raising the C.D. above this figure gave a burnt deposit.

The following solution was made up according to information received from the Bureau of Information on Nickel, to whom the author is indebted for their advice and assistance :—

Nickel sulphate	250–450 grms./litre
Nickel chloride	22 ,,
Boric acid	22 ,,
Nickel nitrate (20% solution)	½–1 cub. cm.

Working temperature about 50° C.
Current density, 15 amps./sq. decm. max. (135 amps./sq. ft.)

It is suggested that the average conditions of working be such that the current density is from 5 to 10 amps./sq. decm. (45 to 90 amps./sq. ft. approximately). The recommended pH value is 5·3 to 5·7. Good white deposits have been obtained from this bath, it being possible to deposit a thickness of 1/1000th inch in 20 mins. The author has not, however, used the bath at the high current densities claimed for it. There is not much doubt as to its ability to function under these conditions, but, in the author's opinion, the temperature required is too high for the average nickel-plating vat, and as the greatest temperature that could be maintained for any time was 38° C., experimental work was somewhat limited in this direction.

The factor of prime importance in operating a nickel-plating bath is control of the acidity or, rather, of the pH value. It is quite useless to rely, as do so many platers, simply on the effect of the solution on litmus paper. Apart from the crudity of the test, the green nickel solution stains the papers and vitiates the results. The most satisfactory test is the colorimetric one, using standard solutions of known pH value, and a suitable indicator. Brom-cresol-purple answers the purpose admirably. There are several comparators on the market to-day which are very convenient and simple to use.

When deciding upon a solution the choice should be influenced largely by the purpose for which it is required. As an example, it may be said that, when plating on zinc-base die-castings, always a difficult operation, a solution buffered by citric acid gives the best results.

If the anodes are rolled and very pure they will sometimes only dissolve with difficulty. In such cases the use of an anode corroder is indicated. The most usual is nickel chloride. Other chlorides may be used, but it is better not to introduce any foreign ions and so complicate the solution. Care must be exercised, if subsequent trouble is to be avoided, with regard to the amount of nickel chloride added. The maximum permissible quantity is about 2 oz. per gallon. If more than this is present there is danger of attack of the article by chlorine, which may occur after the plating has been completed and the article is apparently in good condition. It is better to use as small an amount of any anode corroder as is absolutely necessary. With modern high-speed plating vats and high-current densities, there is no difficulty in getting the anodes to dissolve efficiently. As mentioned before, the use of salts of aluminium is sometimes recommended. The author has tried the addition of aluminium carbonate to nickel vats, but does not regard it favourably on account of its erratic action.

If the acid content of the bath should increase above that required, it is most conveniently reduced by the addition of basic nickel carbonate. This has the advantage of contributing towards the nickel content of the vat. Should the latter tend to become alkaline, sulphuric acid may be added, but this must be done with caution. After each addition of acid enough time must be allowed for its

**Previous article published in May issue.*

thorough circulation before a test is applied. In a large vat this may take some little time.

Organic addition agents are of little use in nickel-plating. It has been shown that these solutions are extremely susceptible to the action of colloids; they tend to produce bright and brittle deposits. The control of colloids in the bath is almost an impossibility; the amount necessary to have an appreciable effect is so small as to be far less than would be accounted for by experimental error in ordinary chemical analysis.

The author has used a solution of the following composition, and found that it will give results as good as any :—

Nickel sulphate	3 lb.
Nickel chloride	1 oz.
Boric acid	2 oz.
Citric acid	½ oz.
Water	1 gal.

This solution was worked at 90° F. Current density 25 amps./sq. ft.

The aim in most work is to produce a deposit of a thickness of 1/1000 in. This is thicker than is usually applied in nickel deposition, but it is the minimum thickness that will give satisfactory results when the article is to be finished by chromium plating over the nickel. Any solution which will consistently produce a deposit of this thickness in about 20 mins. is a fairly good one.

Effect of Temperature, Aeration, and Agitation on the Deposit.

The general effect of raising the temperature of the solution is to cause an increase in the size of the crystals forming the deposit. Bancroft states that lowering the temperature decreases the size of the crystals, and this has also been confirmed by *Blum in the case of copper up to 65° C. The effect with nickel has not been found by the author to be so marked as in the case of copper. The deposits obtained from hot solutions are softer than those from cold vats, and they finish more easily, this being consistent with the increase in the grain size. At the same time, these soft deposits are found to tarnish more readily than the harder kind, their resistance to corrosion and the effects of the atmosphere in general being not so good as when a cold bath is used. If, however, the nickel deposit is afterwards chromium-plated, the deposit from the warm solution will give good results.

Raising the temperature of the solution increases the solubility of the salts, but this is not so advantageous as one might expect. The saturation cannot be increased too far or salts will separate out on cold days. The increase in conductivity resulting from raising the temperature is helpful in preventing "treeing." There is less tendency for nickel to build up on corners of work when the solution is hot than when cold.

It is difficult to study the effect of an increase in temperature alone on a nickel-plating solution. The reason is that such temperature change brings about other changes, the effects of which may completely mask the actual effect of the temperature. Thus, although it is well established that raising the temperature increases the crystal grain size under some conditions, a rise in temperature may bring about a decrease.

The advantages gained from the use of hot plating solution appear to be due to secondary actions. One advantage of the hot solution is that, when using high current densities, there is less tendency to occlude hydrogen in the deposit, and consequently less likelihood of cracking. Deposits from hot solutions do not suffer from internal stress to the same extent as those obtained from cold baths.

Aeration and agitation are essential if high current densities are to be employed. They tend to reduce the size of the crystal grains. This is probably due to the continual replenishment of the metal in the cathode layer and the increase in the number of centres of deposition. This holds if the current density is sufficient to use all the ions brought into the cathode layer. If the current density is higher than this, the cathode layer becomes impoverished, the crystal size increases, and a burnt deposit results. It is, therefore, most important to combine control of current density with both rate of agitation and temperature. This is where difficulty arises in practice, and the author has found that the balance between these variable factors is not so easy to maintain as one could wish.

Agitation is essential if a high-current density is to be used. In this way only can sufficient metal be brought into the cathode layer to allow of rapid deposition. Moving the cathodes is also helpful in keeping them free from adherent bubbles and reducing the tendency to form pinholes. With this latter object in view, it is also essential to filter the solution continuously and efficiently.

If the cathodes are of copper or steel there is usually little trouble in obtaining a good deposit, provided due care is exercised and the vat is kept in proper trim. It often happens, however, that nickel deposits are required upon other metals or alloys, and in some cases it may be almost impossible to obtain a satisfactory result. Die-castings, generally made of a zinc-base alloy, can be very troublesome in this respect. It is most important when dealing with material of this type to see that contact with the cathode rod occurs *before* the article touches the surface of the vat solution. The recovery of such articles (and also any brass objects) that have fallen into the vat should be carried out at the earliest opportunity; only in this manner can the concentration of zinc in the solution be kept down to the minimum.

If the quantity of zinc reaches too high a figure in the vat solution, as shown by the production of black streaky deposits, the work should be removed and the vat worked on scrap material for a sufficient time to remove the zinc or reduce it until it no longer causes trouble. The solution might conveniently be left depositing on iron sheets overnight. The objection to this method of removal is the wastage in power which it causes.

Preparation of Work.

If good results are to be obtained the greatest care must be exercised in preparing work. All grease must be removed and the surface be prepared as finely as possible before the article is placed in the nickel vat. In some cases electrolytic cleaning is advisable.

Trouble can often be traced to undue handling of work after preparation. Finger-marks, for example, are liable to cause the nickel-plate to blister when placed in the chromium solution.

It is very important to allow as short a time as possible to elapse between preparation and plating. This applies particularly to aluminium and its alloys, as well as the zinc alloys referred to above. In such cases, allowing to stand in the air for even one hour may cause enough surface oxidation to spoil the nickel-plate. When sufficient nickel has been deposited, the article must be thoroughly rinsed before finishing.

The time required for deposition will depend, of course, upon the cathode current density. With a good high-speed vat it is possible to deposit 0·001 in. in about 20 mins., although in some cases this rate is greatly exceeded.

The tendency some years ago was to deposit copper upon steel articles prior to nickel-plating. This is not now necessary. Provided the iron or steel has been thoroughly well prepared, no difficulty should be experienced in obtaining a sound deposit. It is sometimes troublesome to get good results on steels of higher carbon content, such as spring steel and bumper-bars, but in such cases etching in a suitable acid solution is often very helpful. The method of cleaning such articles by making them the anodes in a 95% sulphuric-acid vat, is also very useful. A heavy current is passed through the work; it is found that, in a few moments, as cleaning progresses, the current drops considerably. The article is then removed, rinsed in water and potash, to remove all traces of acid, again rinsed in water, and then transferred to the plating-vat.

*"Principles of Electroplating and Electroforming," Hogaboom and Blum.

Correspondence.

Heat-Treating and Forging Some Light Alloys.

December 2, 1932.

The Editor, METALLURGIA.

Dear Sir,—Your extracts of Mr. W. C. Devereux's recent paper published in November's issue are very interesting to us, particularly with regard to the questions of grain growth during prolonged heating.

In this connection we would like to state that all aluminium alloys do not necessarily exhibit the phenomena of grain refining growth when soaked at the forging temperature. Alloys that have been treated by the B.C.L. process of refining, whether they are in the extruded or cast state, do not exhibit the phenomena of grain growth, and it is therefore possible to forge these treated alloys at a considerably higher temperature without the risk of excessive grain growth.

One of the most notable features of B.C.L. refined alloys is the fact that when examined in the chill-cast state there is complete absence of columnar crystals. The addition of titanium in the proper form is also effective, but to a much lesser degree, and whilst it does prevent the growth of large columnar crystals if already present it is not possible to obtain such complete control of the grain size.

We are also interested in that Mr. Devereux dealt with the mechanism of age-hardening, and that prominence was given to the precipitation theory. We do not think that this theory fully explains the mechanism of age-hardening.

If the particles are precipitated they must become visible, but even the ultra microscope fails to detect the presence of precipitated particles. This fact is also confirmed by X-ray spectrum analysis. Considerable age-hardening effects can be obtained from ternary aluminium-zinc-magnesium alloys, which lie well below the solid solution point of both zinc and magnesium.

These effects noted in this type of alloy cannot therefore be explained by the precipitation theory.—Yours, etc.,

Cindal Metals, Ltd., Rainhill, D. R. TULLIS,

December 5, 1932.

The Editor, METALLURGIA.

Dear Sir,—As Mr. Tullis knows, we have tested in rather an extensive way aluminium alloys treated by his Cl process of refining, and our tests proved conclusively that the metal treated by this or the other known degasifying and refining processes exhibit the same characteristics as to grain growth as the alloys mentioned in my paper. Unfortunately, we have not been able to do any tests on Mr. Tullis's B.C.L. process, as although we have had some of this material on order since August, 1931, we have not been able to obtain delivery, but I shall doubt until I have had a chance of testing for myself that the process can possibly retard the grain growth on soaking at forging temperature, as at the moment I am convinced that the question of growth is a function of the time and temperature that the proceeding work has been put on to the material.

Further, in casting in heavy chills metal-treated with the degasifying processes, we have repeatedly found that the macro structure is enlarged, and for forging and extrusion purposes work obviously must be done with large chills.

I do not believe that the absence or presence of columnar crystals is given by any characteristics of the material, or the treatment, but is purely a question of the control of the time in chilling.

This is my opinion after an experience of heavy chilled material of more than 10 tons per day regularly.

I fully agree with Mr. Tullis that no evidence is yet forthcoming to support the precipitation theory, but had he followed my papers fully he would notice that I mention this fact, but that the theory did give something useful to work upon.

I myself am rather more inclined to support the idea of Jeffries as I understand it—that is, that in the atomic dispersion of the soluble heat-treatment constituents it is not the dispersion which produces the maximum hardness, but some intermediate one between it and that at which the particle becomes microscopically visible. There is scarcely any adhesion between the matrix and the constituent of heat-treatment molecules precipitated trom the aluminium crystals, and when these particles get to a certain size the maximum adhesion is produced. The support of this would rather explain the reason why the R.R. 56 alloy will not age harden at normal room temperatures, in so much that it is possible in the comparatively high iron content in this alloy the iron in the form of an Al_3Fe compound interferes with the seeming growth of the particle.

I have not any direct experience with the Al-Mg-Zn alloys, but studying the constitutional diagram, I cannot see in what way this goes to dispute the theory which is given so well in Dr. Budgen's recent book on "The Heat Treatment and Annealing of Aluminium and Its Alloys," as follows :—

> "Age-hardening can occur in an alloy where some constituent is more soluble at high than at lowered temperature, and where rapid cooling fixes this constituent in saturated solid solution. 'Precipitation' of the excess constituent occurs in the form of sub-microscopic particles distributed throughout the mass of solid solution, and this causes the hardening."

—Yours, etc., W. C. DEVEREUX.

High Duty Alloys, Ltd.,
81, Buckingham Avenue,
Trading Estate, Slough, Bucks.

[In view of any possible misunderstanding that may have been responsible for a statement made by Mr. Devereux in the above letter, we called the attention of Mr. Tullis to it and publish his reply.—EDITOR.]

December 12, 1932.

The Editor, METALLURGIA.

Dear Sir,—With regard to the points raised in Mr. Devereux's letter we are in agreement with there being no effect on the grain growth of metal treated by the chlorine process, as this serves primarily to remove dissolved gases, and has no influence in preventing the grain-growth common to the majority of aluminium alloys.

Our contention is that metal which has been fully refined by the B.C.L. process is not so effected, and we are therefore sending ingots of Cindal E11A alloy to Mr. Devereux for him to test. A batch of this alloy, which had been previously remelted seven times, was cast at 950° C. into a red-hot loam mould, the metal taking four hours to cool to 400° C., and the resulting effect upon the grain size was inappreciable in relation to the severity of the test.

We feel sure Mr. Devereux has made a mistake with regard to our having an order for a Cindal B.C.L.-treated alloy, as we find that we have only treated R.R. 50 supplied by him, and this was sent in in September, 1931, which is, of course, another matter.—Yours, etc.,

D. R. TULLIS.

Cindal Metals, Ltd., Rainhill.

Electric Furnace Heating.

November 30, 1932.

The Editor, METALLURGIA.

Dear Sir,—I was interested to read in your November issue Mr. George Turner's article on "Electric Furnace Heating," and especially his description of a furnace for the "bright" annealing of copper and brass sheets. Using an atmosphere of commercial nitrogen (O_2 below 3%) or carbon dioxide, he claims to be able to produce sheets without a detrimental surface finish.

In the case of copper this statement could stand, except that there would be slight oxidation if annealed in commercial nitrogen containing even 1% of oxygen. Steam has been found to give perfect results if certain minor precautions are taken, and I cannot see any reason for

employing more expensive gases, such as nitrogen and carbon dioxide, for producing the same or inferior results.

In the case of brass his statement is not only misleading but incorrect. I have conducted a series of experiments on the effect of various atmospheres on brass (70/30 and 60/40). Carbon dioxide has been found (and this is confirmed by other investigators*) to be definitely oxidising, as the zinc constituent will decompose CO_2 with the formation of zinc oxide. Commercial nitrogen will also show a distinct oxide discoloration due to its oxygen content. Moreover, neither of these gases will overcome the difficulty due to the loss of zinc from the surface, which produces a red discoloration.

To my knowledge no bright annealing process other than that which I have developed in conjunction with the firm with which I am associated has yet overcome completely the difficulties in the bright annealing of brass.—Yours, etc., A. G. ROBIETTE.

C/o Electric Furnace Co., Ltd.,
17, Victoria Street, London, S.W. 1.

[We understand that the bright annealing furnace to which Mr. Robiette refers is used for the bright annealing of copper, and that steam has been used in lieu of nitrogen and carbon dioxide, with quite good results. An error has undoubtedly occurred in regard to brass annealing, probably due to meagre information available at the time on that particular furnace.—EDITOR.]

NICKEL-CLAD STEEL PLATES.

IN recent years there has been developed a composite product consisting of nickel rolled on steel. This material, in the form of nickel-coated steel sheet and strip, has been on the market for some time, but the production of nickel-clad steel plate has only been perfected within the last three years. Its availability is now providing a solution to many of those problems where thick section, strength, and corrosion-resistance are required at moderate initial cost.

Nickel-clad steel plates are plates protected on one side by a covering of malleable nickel. This covering, which has all the corrosion-resisting and other properties of ordinary commercial hot-rolled sheet nickel, is firmly bonded to the steel, and the mechanical properties of the composite plate are such that it can be treated by the designer as a solid steel plate.

The most important factor in the manufacture of nickel-clad steel plates is the production of a true bond between the surfaces in contact. Fortunately, nickel and iron are mutually soluble in all proportions, and if the surfaces in contact are kept clean during the heating process, it is possible to obtain a good bond simply by hot-rolling. This having been obtained, the working properties of nickel and steel are sufficiently alike to permit the rolling of the composite slab to whatever thickness is desired.

Since nickel-clad steel plates are made throughout by hot rolling, the normal finish is that of hot-rolled steel and hot-rolled nickel. The nickel is covered by a thin, tightly adherent, and glossy oxide film, dark olive brown in colour, which has very good corrosion-resisting properties. If necessary, this thin film may be removed by subsequent treatment of the nickel surface.

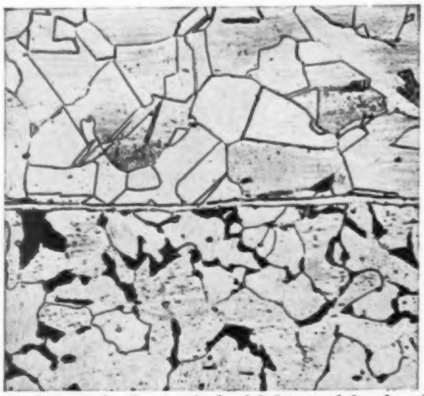
The thickness of nickel may be varied at will to suit the particular service conditions. Perhaps the most widely used nickel-clad plate, according to a booklet published on the subject by the Mond Nickel Co., Ltd., and prepared by the Research and Development Department, is ¾ in. thick, having a nickel covering of 10%.

A narrow band between the nickel covering and the steel base plate constitutes a bond or alloy area (consisting of a solid solution of nickel and iron), which is formed when the two metals are brought into intimate contact under pressure at elevated temperatures. This method of bonding differs from autogenous welding in that the bond is produced at temperatures below the melting point of either metal, being obtained by the interdiffusion of iron and nickel. The continuity of metal throughout the section of the composite plate is of value in many applications where heat transfer is of importance; no air film being present as occurs when a separate lining of sheet metal is adopted.

In the fabrication of nickel-clad steel equipment, cold operations, such as bending, flanging, forming, etc., can all be carried out exactly as in the case of steel. For cold pressings it is generally necessary to use annealed plates. Hot working also follows the same procedure as for steel so far as temperature, tools, and methods of working are concerned. It is essential, however, to prevent possible injury to the nickel by exposure to sulphurous furnace gases, both when annealing for cold pressing and when heating for hot working.

As the applications of nickel-clad steel plates are all concerned with problems of corrosion resistance, special interest centres on joints. It is necessary in the majority of plant parts made in this material, to have an unbroken nickel surface, and continuity is obtained by welding with nickel. If this were not done, galvanic action would be set up, resulting in enhanced corrosion of the steel base-plate at the joint. Welding may be carried out either by the metallic arc method or by the oxy-acetylene flame, but for heavy steel plate the former method is more generally employed.

Although the production of nickel-clad steel plates on a large scale has been undertaken only within the last three years, this material is already being extensively employed,



Photomicrograph of a typical nickel-to-steel bond × 200.

particularly for such purposes as forced circulation vacuum evaporator bodies, in the manufacture of caustic soda; hoppers, dye kettles, and tanks for large reel tank-dyeing machines, in the dyestuff industries; mixer bodies of steam-jacketed mixers for cellulose acetate manufacture; tanks for plastics manufacture; agers, sizing drums and peroxide bleaching kiers in the textile industries; storage tanks, boiling kettles, and cooling machines in soap manufacture; hot-water heater tanks in laundry equipment; bottoms of kettles in varnish manufacture; equipment handling fruit and vegetable juices, butter, margarine, syrups, etc., in the foodstuffs industries.

The properties of nickel-clad steel plate make it admirably suited also for such parts as outside shell of centrifugal extractors, hydraulic press plates, filter tanks, chutes, conveyer pans, elevator buckets, settling tanks, rotary drier shells, condenser shells, storage bins, and for all heavy equipment where the properties of nickel are desirable, but where solid nickel would be too costly, and where the use of a separate lining is not practicable.

It must be remembered that the useful service obtainable from nickel-clad steel plate is entirely dependent on the life of the nickel covering, and therefore on the thickness of the nickel. The employment of this material should not be resorted to when the conditions are such that the use of a solid corrosion-resisting metal or alloy would be justified. On the other hand, there can be no doubt that it is supplying a very pressing need.

* Coriolis and Cowan, "Industrial and Engineering Chemistry," January, 1932.

Recent Developments in Tools and Equipment

AN AUTOMATIC DROP STAMP.

THE extensive use of stampings in a wide range of industries, particularly in motor-car manufacture and aeroplane engines, is largely due to the efficient machines now available for this class of work. Drop stamps in particular have been developed considerably during recent years, and an order recently received by Messrs B. and S. Massey, Ltd., of Openshaw, Manchester, from Australia, prompts the thought that a description of the "Massey" friction drop-stamp with "Simplex" automatic gear may be helpful to readers.

The ordinary hand-pulled "Massey" friction drop-stamp is well known, but many do not appreciate that these stamps can be arranged to operate automatically. This automatic action is useful chiefly in stamps up to about 20 cwt., suitable for the production of stampings of medium size. A 12½-cwt. stamp, on which the "Simplex" automatic unit is clearly visible in front of the left-hand standard, is shown in Fig. 1. The unit itself is shown in Fig. 2, from which it will be seen that it consists essentially of a toggle arrangement which, under the influence of a trip-rod, alternately allows and prevents a spring from actuating the pulling cord of the stamp, just as a driver would do.

Fig. 1.—A 12¼-cwt. stamp with Simplex automatic unit.

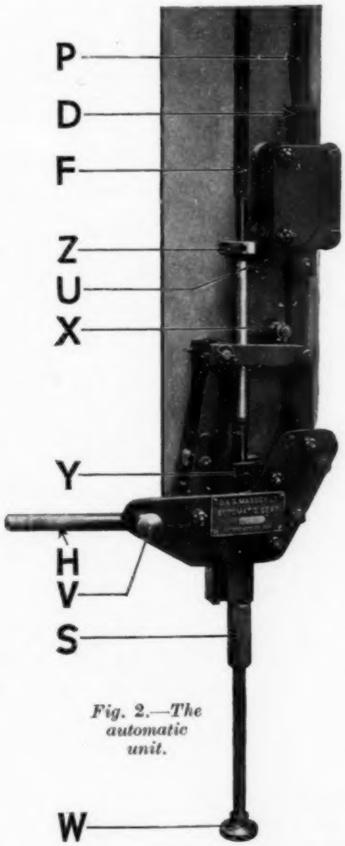


Fig. 2.—The automatic unit.

The rod D, on which the spring P presses, is fastened at its upper end to an auxiliary pulling cord, and when the toggle mechanism allows the spring to push the rod down the pulling cord is pulled and tightens a friction band on to a constantly rotating, water-cooled drum. Thereupon the tup of the stamp rises and at the same time the trip-rod F also rises, reproducing the movements of the tup in miniature. As it rises it brings a cam Y into operation against a roller, thus restoring the toggle to the position shown, and rendering the spring inoperative. This releases the friction band and allows the tup to fall. As the trip-rod F also falls the collar Z strikes the lip U of the toggle, which is thereby pushed across the dead centre, so that the spring again causes the tup to rise. Both the cam Y and the collar Z are adjustable in position, so that the length of stroke and point of pick-up can be adapted to suit the work in hand and the dies being used. The stamp itself is of very rigid construction, and the standards are adjustable on the anvil block by wedges and bolts to take up any wear on the double-vee slides. The tup is therefore guided with absolute accuracy so that offset stampings are reduced to a minimum.

When the automatic gear is in action the stamp is controlled by foot-lever, and as long as this foot-lever is held down the tup continues to rise and fall, but the automatic gear can, by a simple movement of the hand-lever H, be cut out of action, and the stamp can then be controlled by hand-pulling cord in the usual way. Immediately the foot-lever is released the tup rises to the top of the stroke for which the mechanism is set, and is held suspended without consuming power.

When operating automatically the blows may be modified by raising the foot lever slightly. This allows a supplementary catch, not shown in the illustration, to come into operation, and short stroke blows are obtained. Single blows are just as readily made by depressing the foot-lever until the blow has been struck, and immediately releasing it so that the tup is again held up.

A feature of this automatic gear is the few wearing parts it possesses and the ease by which they can be replaced if necessary. Ample lubricating facilities are provided, and the stamps are claimed to be very quiet in action, in which respect they differ from those stamps in which trips for the automatic action are actuated by the tup.

NEW TYPE FACING CUTTER.

A NEW type facing cutter has been developed by Samuel Osborne and Co., Ltd., Clyde Steel Works, Sheffield, which works on the same principle as a circular or button tool used in wheel lathes. The body of the cutter is made of special steel, and the teeth, as will be seen in the accompanying illustration, are circular discs or blades, which can be made of the maker's "Double Musket" high-speed steel, of S.O.B.V. cutting alloy. The company recommend the latter material.

The teeth are held in position on the body by hardened retaining screws, and they can be rotated on a centre holding screw, so that they can be used over the whole of their circumference before regrinding is necessary. The bodies can be made at size, but the blades are standardised at 1½ in. diameter. With this diameter and calculating on a ¼-in. arc of contact when cutting, the blade gives fully 18 cutting edges on its circumference. This is a feature which should save considerable time, because, with the ordinary inserted tooth-facing cutter, when one tooth is dulled and needs sharpening all the other teeth have to be ground up to correspond. In this new facing cutter, how-

ever, it is only necessary to loosen the tooth and rotate it to a new cutting face.

A new type of facing cutter.

This new facing cutter has the advantage of the scraping or trailing action of a face cutter with a left-hand spiral, together with the positive cutting angle of a cutter with a right-hand spiral. In addition to these advantages, it is claimed, as a result of tests, that greater speeds and feeds can be employed than with the ordinary plain tooth cutter. We understand that the price of this new cutter, the design of which is registered, compares favourably with the inserted tooth type.

A PORTABLE OXYGEN GENERATING PLANT.

FOR many classes of work involving oxy-acetylene welding the oxygen must be transported long distances in steel cylinders. A number of these cylinders or bottles combined to form a small battery, are set up near to the acetylene generator on trucks which can be moved about according to the location of the work. In some instances, when work is being conducted over trackless and mountainous territory the weight of the bottles constitutes a difficult transportation problem. Large loads of steel containers with relatively small gas quantities must be carried and maintained at the point of consumption. With the progress of the work this point advances, increasing the distance from the supply plant, and frequently causing expensive interruptions in operation.

The difficulties associated with this procedure are claimed to be overcome by the recent development of a portable oxygen-generating plant built by I.G. Farbenindustrie A.G. This plant is started by means of a dry powder known as "Oxygal," which is packed in hermetically sealed sheet steel drums and may be stored for an indefinite period. When the oxygen generator is to be used this powder is charged into a horizontal retort and fired by means of an igniting powder, and the oxygen generation is started. A pound of this Oxygal will produce about 4·75 cub. ft. of oxygen gas at a pressure of about 210 lb. per sq. in. in the oxygen generator. By means of a filter, which is integral with the plant, the oxygen is freed from any mechanical impurities it may contain, with the result that the oxygen produced is claimed to exceed 99% purity. A reducing valve provided on the generator permits adjustment of the pressure to that required for operation, which may be maintained constant. The pressure in the generator is sufficient for welding work of any kind, and great enough also for cutting material up to about 4 in. thick, provided that the cuts required are not too long. The generator is equipped with two retorts for the reception of the Oxygal powder, so that continuous operation can at all times be maintained.

The plant consists of a tractor and trailer, the generator being located on the latter, on which can also be carried enough Oxygal for generating 5,300 cub. ft. of oxygen at the pressure required for welding. This corresponds to the contents of about 25 normal steel cylinders at present in use for the purpose. The Oxygal, however, is much more easily transported, and may be stored in any quantity at any desired point. Although the price is higher than that for bottled gaseous oxygen, a large reduction in cost is effected by the absolute independence from a stationary generating plant, and its constant readiness for operation even in the most out-of-the-way regions.

This development is likely to open the most difficult territory to the use of autogenous welding, because it appears to overcome the serious drawback resulting from the employment of time-consuming traffic to and from the oxygen-generating plant. With this new plant the stock of vehicles is restricted to the number of trucks or cars necessary for continuous operation at the points of work proper. The installation is also useful as a stationary plant, where high transportation costs would be a serious disadvantage to the use of bottled oxygen gas.

PROTECTION of STEEL WATER TANKS.

IT is well known the protection of steel water tanks from rust and corrosion is a troublesome problem, especially as they are always partly in contact with water; the same applies to all exposed structural steel, such as pit-head gear, lighthouses, docks, and harbours, gasholders, and oil tanks, to mention only a few examples. It is therefore of interest to note the methods adopted by the Union Pacific Railway in the United States, which is a huge system with about 10,000 miles of track. At 230 different railway stations in this system are 250 steel tanks, varying in capacity from about 5,000 to 850,000 gals., in some cases being as much as 100 ft. in diameter, supplying over 1,250,000 gals. of water per day. The total capital represented by these tanks, which have a total capacity of over 25,000,000 gals., is several million dollars, while the Union Pacific system encounters almost every possible condition of climate and quality of water.

As a result of extensive experience, red lead paint is used as the standard method of protecting all these tanks throughout the entire system, painting being effected every 4–10 years, according to the conditions, the results being excellent. Before erection, the tanks are thoroughly painted with red lead paint, then after erection the exterior of the tanks is given two more coats of the paint, suitably tinted, while a further three coats of paint are given to the interiors. The first is a brown colour made by using 10 oz. of lampblack, 6 oz. of Japan drier, and 2 lb. of pulverised litharge to each gallon of red lead paint. The second coat is similar, except that half the amount of lampblack is used, while the third has no lampblack. Non-setting red lead is used for the paint, containing 94% actual red lead (Triplumbic Tetroxide Pb_3O_4), and less than 6% litharge (Lead Monoxide, PbO), allowing, therefore, of storage in containers without hardening. The addition of a further amount of litharge when the paint is applied results in an extraordinarily hard paint film, highly resistant to water, and the same methods are used for repainting.

The tanks are cleaned by scraping and wire brushing before painting, while the steel must be perfectly dry, with full time allowed for drying between each coat of paint.

The beneficial action of red lead paint for the protection of iron and steel from rust and corrosion, especially under the conditions created by a damp atmosphere, is of a dual character. Not only does a dense, heavy mechanically protective layer of paint result, but also the product has a direct inhibiting action on rusting and corrosion, because of its chemically active properties forming a resistant passive film of oxide of iron on the surface of the metal.

Some Recent Inventions.

The date given at the end of an abridgement is the date of the acceptance of the complete Specification. Copies of Specifications may be obtained at the Patent Office, Sale Branch, 25, Southampton Buildings, London, W.C. 2. at 1/- each.

Making Seamless Tubes.

UNDER the above heading reference was made on page 128 in our August issue to a method of making seamless tubes for which a British Patent was applied by the Timken Holding and Development Co., Wilmington, U.S.A. Objection was raised, however, because of a prior Patent No. 250,712, and it was withdrawn. In view of the previous reference, it will be of interest to consider the main features of the method of production embraced by this latter patent, which was granted to Rheinische Apparatebau G.m.b.H., a Germany company, and Mathias Peters, a German citizen. It comprises a process by which rolled tubes are produced from a short ingot, made by the centrifugal process, which is conveyed to the rolling mechanism while still hot. Arrangements are included for maintaining a suitable rolling temperature during the transport of the ingot from its mould. The object of the process is to limit the number of operations usually involved, and reduce time, labour, and expense in the production of seamless tubes.

Various arrangements may be employed for carrying this process into effect. In one method the mould, which is closed at its lower end by a cover, is mounted on bearings, and is rotated by toothed gearing. At the inlet end a casting truck receives the molten metal from a ladle. After casting the cover is removed and the hollow ingot received by the conveyer, which transports it to the rolling mechanism, as shown in Fig. 1. The ingot may be passed through a chamber to maintain its temperature heat

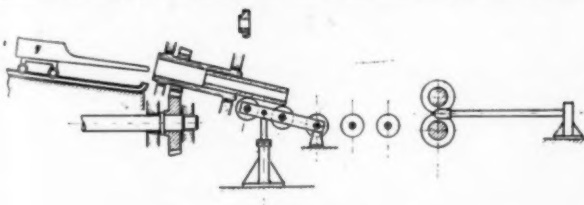


Fig. 1.—General arrangement.

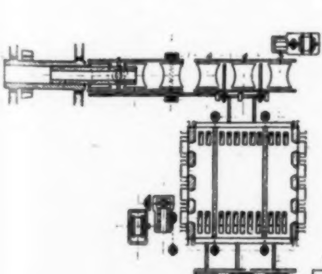


Fig. 2.—Plan showing introduction of a soaking pit.

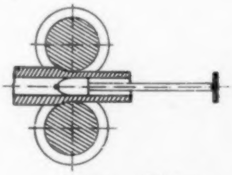


Fig. 3.—Rolling mechanism.

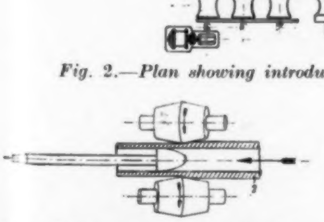


Fig. 4.—Skew roller arrangement.

or cool it, according to requirements, before rolling, and a Pilger mill, a two-high mill, or a continuous mill may be used for the rolling operations. In Fig. 2 an arrangement is shown for passing the ingot through a soaking pit, placed between the mould and the rolling mechanism. The rolling may be performed on a mandrel by rollers as in Fig. 3, or as shown in Fig. 4.

The method is preferably adopted for the production of seamless rolled tubes in wrought iron or steel, and it is claimed to be efficient and economical in practice.

The Driving of Rolling Mills.

IN rolling thin sheets, where the top roll is driven by the bottom roll through spur gearing, back-lash in the teeth, due to the rise and fall of the top roll, causes surface irregularities on the finished sheets. In order to overcome this difficulty, an arrangement has been devised in which

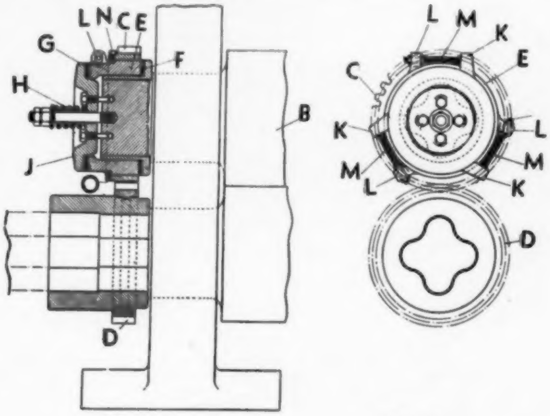


Fig. 1. Fig. 2.
Improvement in arrangements for driving rolling mills.

the driven roll can slip under load whilst driving engagement obtains in the spur gearing. In this arrangement, the driven roller, when not under load, is driven through the medium of a friction-clutch device, which is operated by a toothed ring mounted on the driven roll and meshing with a spur-wheel or toothed ring on the driving roll, a resilient connection obtaining between the toothed ring and the friction-clutch device of the driven roll for maintaining driving engagement of the teeth of the spur gearing of the driving and driven rolls. The friction-clutch device may comprise a slip-ring mounted so that it will rotate over a flanged sleeve fixed to the end of the driven roll. The arrangement is illustrated in Figs. 1 and 2, the former being an elevation, partly in section, of one form of rolling-mill drive incorporating the improvement, and the latter an end view of the drive.

The roll B in Fig. 1, driven through a toothed ring C from the spur-wheel D of the roll, is allowed to slip under great stress by mounting the toothed ring C on a slip-ring E, between annular rings F, G of friction material on the roll end, the friction being varied by readjusting the spring pressure H on the cap-end J, and when the roll slips or rises and falls the teeth are kept in engagement without back-lash by resiliently mounting the toothed ring C on the slip-ring E by means of lugs K on the slip-ring connected to lugs L on the toothed ring by springs M, thereby allowing limited relative rotation of the toothed ring C on the slip-ring E. The toothed ring C is held against axial movement by a stud N projecting into an annular groove O in the slip-ring E.

373,783. THE BRIGHTSIDE FOUNDRY AND ENGINEERING CO., LTD., and ALFRED F. DIXON, of Newhall Iron and Engineering Works, Sheffield. June 2, 1932.

Nitrogenising Iron and Steel.

THE nitrogenisation of alloys of iron, steel, and cast iron is carried out in the presence of one or more halogen compounds. In an example, a steel containing 0·3% carbon, 0·2% silicon, 0·3% manganese, 1·5% chromium, and 1·2% aluminium is sprinkled with calcium chloride and nitrogenised for 48 hours at 500° C. Ammonium chloride and bleaching powder may also be used. The alloys treated contain one or more of the metals, aluminium, chromium,

molybdenum, vanadium, and titanium, and further elements such as silicon, manganese, nickel, and tungsten may be incorporated in the alloys.

366,838. KRUPP AKT.-GES., F., Essen, Germany.

Checkerwork for Furnace Regenerators.

MODIFICATIONS in the shape and method of setting the checkerwork bricks in furnace regenerators are claimed to provide both increased heating surface with a minimum of draught, and increased heat storage capacity. These improvements refer particularly to the checker-brick structures in the reversible air and gas chambers of open-hearth or reheating furnace regenerators. Each brick of the checkerwork is substantially rectangular in shape, having an elongated slot through it, and the corners off

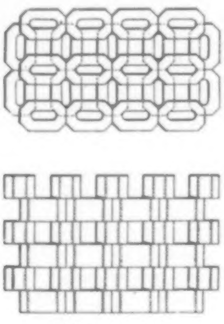


Fig. 1.

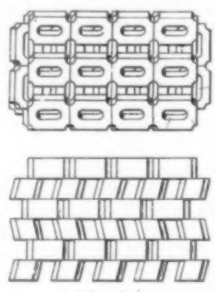


Fig. 2.

to form with the adjacent bricks V-shaped grooves, or cut away to form quadranted grooves, each groove being arranged to register when built up as in Fig. 1. In this arrangement the passages between the bricks are at right angles to the passages in the layers immediately above and below. In a modification of this arrangement the bricks are rhomboidal in vertical cross section, as in Fig. 2. In each case the bricks are built in staggered formation, as shown, so that vertical and horizontal gas passages are formed between them.

377,342, THE UNITED STEEL COMPANIES, LTD., and ALEXANDER MCKENDRICK, of Sheffield, July 28, 1932.

Liquid Fuel Burners or Atomisers.

A LIQUID fuel burner which is claimed to provide more efficient atomisation of the fuel is shown in Fig. 1. It is designed for furnaces, and is of the type which includes a

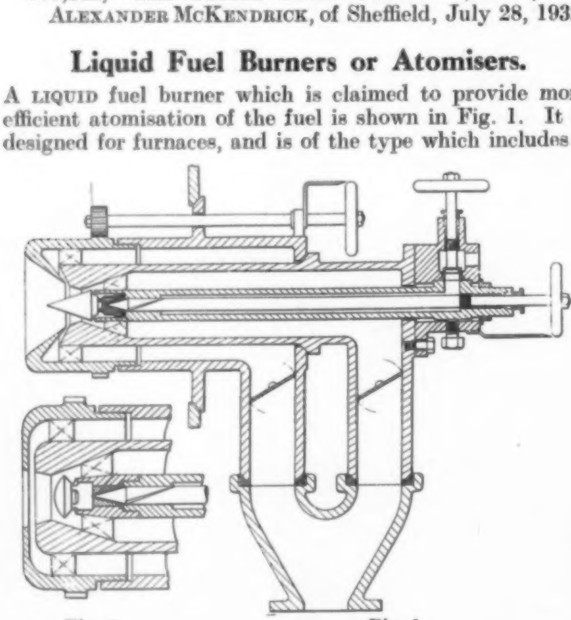


Fig. 2. *Fig.* 1.

central oil passage through which passes a spindle to control the supply of oil to the burner jet, and possessing a diaphragm at its end with which it co-operates, one or more helical, tapered grooves in combination with a fine screw thread by which longitudinal movement of the control spindle is effected by rotation of the latter. The oil-supply tube through which the control spindle extends is provided at its end with a button against which the oil impinges, the button being supported at a distance from the end of the oil tube, so that an oil jet is formed between the button and the end of the tube.

The oil is atomised primarily by air discharged through a nozzle on the burner body, and secondarily by air discharged through an adjustable nozzle on a sleeve surrounding the body. A pocket in the nozzle causes the secondary air to become heated by the burner flame before discharge. The air supplies are regulated by dampers and are whirled by vanes in the nozzles. One nozzle may be arranged to direct the air in varying directions in regard to the direction of the oil stream. The button is carried by a sleeve screwed in or on the tube. By inserting a washer between the sleeve and the diaphragm the jet aperture may be varied. The tube is removably secured in the body by a screwed stud, leakage of air being prevented by an adjustable blank. In a modification shown in Fig. 2 the button is attached to the sleeve, which clamps the diaphragm in position. The oil emerges from the diaphragm into a recess in the sleeve, and is discharged into the primary air stream through the jet apertures.

377,821. CORNELIS ZULVER, Great St. Helens, London, and SWINNEY BROS., LTD., Morpeth, August 4, 1932.

The Precipitation Theory.

VARIOUS theories have been expounded to account for the increase of strength obtained in certain aluminium alloys as a result of heat-treatment. These were referred to by Mr. W. C. Devereux in a lecture delivered recently before the Coventry Branch of the Royal Aeronautical Society on the manufacture and use of light alloys. In an alloy, he said, in which some constituent is more soluble at high than low temperature, the constituent going into solid solution and is fixed in solid solution by rapid cooling, being supersaturated and metastable at lowered temperature, there is a natural tendency, slowly at ordinary temperatures, and more rapidly if the temperature is slightly raised, to precipitate out of solid solution some of the dissolved constituents. This precipitation occurs in the form of sub-microscopic particles distributed throughout the mass of the solid solution and causes hardening and strengthening. This is the theory that has been expounded to account for the phenomena.

There is no direct evidence that such precipitation occurs, as at even quite high magnifications no micrographic evidence is forthcoming. The theory is, however, useful in giving something understandable to work upon until further evidence is forthcoming. This phenomenon occurs with alloys such as "Duralumin," and working, bending, etc., can be carried out much more effectively immediately after the solution treatment than before age-hardening has occurred, but after even 24 hours the alloy becomes increasingly difficult to work. In the case of the R.R. 56 alloy, however, it is possible to keep it in this very ductile state for considerable periods, extending into some months; therefore the material can be supplied with the high-temperature treatment carried out—which is more easily carried out in the supplier's works than in most aircraft factories; then, after suitable working or bending that may be necessary has been done on the part, simple precipitation can be carried out at an elevated temperature of from 160° to 200° C.

It is supposed that the high iron content is responsible for the interference in precipitation at room temperatures in the case of this alloy. Again, no direct evidence is forthcoming, but it is possible that in the atomic dispersion of the soluble heat-treatment constituents it is not the dispersion that produces the maximum hardness, but some intermediate one between it and that at which the particles become microscopically visible. There is scarcely any adhesion between the matrix and the constituents of heat-treatment molecules precipitated from the aluminium crystals, and when these particles get to a certain size the maximum adhesion is produced; it may be, then, that the iron in the form of an Al_3Fe compound interferes with the seeming growth of the particle.

Business Notes and News

Commemoration in France of the Basic Process.

On December 5 there took place at Paris an interesting ceremony which was organised by the Société des Ingenieurs Civils de France in commemoration of the fiftieth anniversary of the introduction into France of the basic process of steel-making, universally known on the Continent as the Thomas Process, so named after its principal inventor. In response to a special invitation from Professor Portevin to the Iron and Steel Institute of Great Britain, to send a delegation, Colonel Sir Charles Wright, Bt., K.B.E., C.B., President, Mr. F. W. Harbord, C.B.E., Past-President, and Mr. G. C. Lloyd, Secretary, attended the celebrations.

Before the official proceedings began, Mr. Albert Lebrun, President of the Republic, received the British delegates in private audience at the Elysée, and extended to them a most cordial and friendly welcome, in the name of the French Republic. The President of the Republic further honoured the proceedings by presiding afterwards at the Ceremonial Meeting of the Society of Civil Engineers of France, at which addresses were successively presented by the following:—Dr. L. Guillet: "History of the Basic Process"; Mr. P. Pierard: "Basic Process in the Converter"; Mr. L. Baclé: "The Basic Process in the Open-Hearth"; Mr. E. Mathieu: "The Basic Process in the Electric Furnace"; Mr. L. Crussard: "The Iron Ore District of Lorraine."

The French Organisers of the arrangements were particularly delighted to welcome Mrs. Thompson, sister of the late Sidney Thomas, who, in company of her son, Sidney Thompson, had made the journey to Paris with the special object of being present at the ceremony in honour of her brother.

All the English guests were afterwards entertained to dinner privately at the French Automobile Club.

The arrangements terminated on December 6 with a visit to the Cemetery at Passy where a wreath was laid on the tomb of Sidney Thomas. It was interesting to note that the bronze wreath which, at the instance of Dr. Guillet, had been attached to the tombstone on the occasion of the Institute's visit in 1921 was still in its original position.

Commercial Operation of the Salerni Coal Process.

Experiments have been in progress at a special plant in Sheffield with the object of determining the commercial possibilities of the Salerni coal-refining process. The plant has been in operation for some months under very careful supervision, and the results achieved have been sufficiently successful to warrant the laying down of plant for the commercial exploitation of the process in this country.

This is a development of considerable importance, as the success of this first commercial plant will result in the construction of many more similar plants. The contract for this plant will afford some months of valuable work and will absorb a considerable amount of high-grade steel of proved heat resistance and durability.

It is claimed that the process produces a fuel which is suitable for household or other purposes, is practically smokeless, gives a pleasing flame, retains gas of rich quality, and renders available oil that is superior to natural oil as a fuel for Diesel engines and motor-cars.

Should the process prove a commercial success it is not difficult to visualise the time when British coalfields will also acquire national importance as oilfields. It has been estimated that the value of the oil yield under this principle would result in a saving to the country of many millions of pounds per annum.

New Oxide Preservative for Aluminium

We understand that the Lanta Werke, the largest producer of aluminium in Germany, has developed a method of producing a thin oxide coating on aluminium which protects it from corrosion. The chemical composition of the protective coating is said to be identical with corundum and to possess the same hardness. The new product is claimed to be non-porous and colourless, and does not change the appearance of the metal. The coating may be produced in different colours and, as no subsequent lacquering or other protective coating is necessary for aluminium parts, automobile interests are considering the material in the construction of light cars built essentially of aluminium and plywood.

Effects of Duties on Steel Imports.

The condition of the iron and steel industries in this country prior to their feeling the effect of the new tariffs on imported iron and steel is indicated in the report of the Steel Industries of Great Britain and The United Steel Companies, by Mr. W. Benton Jones, chairman of both companies, given at the recent annual general meeting. The report referred to the financial year ending June 30, 1932, during which the importation of foreign steel continued. In November last this importation was accentuated in anticipation of possible protection under the Abnormal Import Duties Act, and again in February in anticipation of a general tariff; thus, it cannot be said that the companies received any assistance during the time covered by the review.

The demand for heavy steel for constructional purposes has not increased since the end of the financial year, nor has there been any increase in demand for any kind of steel for railways or shipbuilding, but in the more general requirements Mr. Jones reported a small improvement which had been growing gradually since October. This encouraging sign, to some extent, appears to be the effect of protection, because many buyers who in the past have purchased imported steel are becoming accustomed to buy British steel.

Important Agreement of Two British Furnace Firms.

We are informed that Birmingham Electric Furnaces, Ltd., Birlec Works, Tyburn Road, Erdington, Birmingham, and Wild Barfield Electric Furnaces, Ltd., Elecfurn Works, North Road, Holloway, N. 7, have recently reached an agreement between themselves for the interchange of information and rights under their respective patents and patent applications relating to electric furnaces employing centrifugal fans and to the air circulation methods used with such fans.

The arrangement will give the furnace users the benefit of the combined experience of both these well-known firms in respect of fan furnaces, and will enable the growing demand for low-temperature operations, such as the tempering of steel, and the heat-treatment of aluminium and its alloys to be met in an increasingly efficient manner.

Further research and experimental work in connection with fan furnaces is being carried out by both firms, and the ultimate results will, it is believed, be of value to all manufacturers whose processes require heat-treatment.

New Source of Precious Minerals.

A new and rich source of radium, and a mineral area yielding gold and silver, recently found in Northern Canada, near the Great Bear Lake, some 35 miles south of the Arctic Circle, was described by Major Bernard Day, the Canadian engineer, in an address to the Institute of Mining and Metallurgy in London.

He predicted that this area in Canada would be as valuable as the Katanga area in the Congo, which produces the radium supply for the world. At present the marketing of radium is almost entirely controlled by the Belgian interests in Katanga.

Railway Experiment with Heavy Fuel-Oil.

A heavy fuel-oil locomotive has been completed at the Derby works of the London Midland and Scottish Railway Co., which is the first to be constructed at the works of any British railway company. Designed for shunting purposes this locomotive has been built to ascertain whether economies can be secured by the use of heavy fuel-oil for this purpose.

A particular feature of this all-British locomotive is the design of the transmission gear, which is capable of absorbing 400 b.h.p. continuously when running at normal speed. The main shaft of the motive unit is coupled directly to a pumping unit, and this pump transmits its power hydraulically to the transmitter unit. The latter is capable of variation in speed from zero to the equivalent of a locomotive speed of 25 m.p.h.

The heavy oil engine is equipped with a self-starter which takes the form of air reservoirs maintained at a pressure of 300 lb. per square inch by a 5 h.p. air compressor. When running this is driven from the main shaft, but a small petrol engine is provided to charge the reservoirs when the locomotive is not running. The brakes are also operated by compressed air. The locomotive carries 125 gallons of fuel-oil and 134 gallons of water.

It is understood that exhaustive tests will be carried out during the next few months by the L.M.S. engineers under varying conditions, the results from which will have a considerable influence on future construction programmes.

Some Recent Contracts.

Craven Brothers (Manchester), Ltd., have recently secured a large order for axle plant for the Russian Government. The plant is to be installed in a new works which is being built and equipped to deal ultimately with 270,000 axles per annum. The machines being supplied by Craven Brothers are :—Semi-automatic electrically driven parting-off, centring, and journal shouldering machines; semi-automatic heavy type, high-speed improved double axle roughing lathes; semi-automatic high-speed improved double-axle finishing lathes; semi-automatic electrically driven axle journal burnishing lathes. The order was secured in the face of serious competition from Continental, particularly German, machine tool manufacturers.

Craven Brothers (Manchester), Ltd., have also received orders from Home Railways and firms in this country for machine tools which include an electric driven 6-in. centre repetition axle lathe; an electric driven portable billet drilling machine; three Fleming patent propelling gears; a 9-in. centre end-driven motor-car crankpin turning lathe; a 7½-in. centre centrally driven motor-car crankshaft turning lathe; a steam-driven spring scragging machine; two 4-ft. wheel turning and grinding machines; and an axle journal returning and burnishing lathe.

Merryweather and Sons, Ltd., have received from the London County Council a repeat order for three super-type motor fire engines for London.

Ransomes and Rapier, Ltd., Ipswich, have received an order from the L.M.S. Railway for five locomotive turntables of the "Mundt" type. Two turntables of 60 ft. diameter and one of 55 ft. diameter will be installed at Kentish Town Depot and two others, of 55 ft. and 50 ft. diameter, respectively, at Cricklewood Depot.

English Steel Corporation, Ltd., have received an order for strip stainless steel to be used in the Mersey Tunnel. A 6 ft. 6 in. dado of black glass is to be built along each side of the tunnel and this is to be faced, top and bottom, with 1¼ in. by ½ in. stainless steel strip. About 25 miles of this strip will be required.

Messrs. John I. Thornycroft and Co., Ltd., have received an order for a 70-ft. auxiliary motor yacht which is to be built at their Woolston yard, Southampton. The boat will be of 52 tons Thames measurement, with a length between perpendiculars of 59 ft., a beam of 15 ft. 4 in., and a draught of 9 ft. She will be equipped with a Thornycroft 30-b.h.p. petrol engine with reducing gear.

Messrs. Hadfields, Ltd., Sheffield, have received an order for the first big retort for the commercial exploitation in this country of the Salerni coal-refining process. The order was placed by Sir Eric Hambro, the banker.

The English Steel Corporation, Ltd., Sheffield, has been awarded the contract for the whole of the forged boiler drums for six Stirling boilers to be installed in the new power station at Fulham. The value of these orders is estimated at between £80,000 and £90,000.

Vickers, Armstrong, Ltd., Barrow, has been awarded a contract for a submarine by the Admiralty.

The Sturtevant Engineering Co., Ltd., Queen Victoria Street, London, and Walker Bros. (Wigan), Ltd., have been awarded the contract for electrically driven fans for the Mersey Tunnel. The value of this order is stated to be almost £33,000.

The Caledon Shipbuilding and Engineering Co., Ltd., Dundee, have received an order from Alfred Holt and Co., Liverpool, for a passenger and cargo motor ship of about 3,500 tons gross. The propelling machinery is to be supplied by Messrs. Burnmeister and Wain, of Copenhagen.

John I. Thornycroft and Co., Ltd., Basingstoke, Hants, have received orders from the London and North Eastern Railway Co. for 14 "Bulldog" vehicles; and from the Indian Stores Department, Delhi, for four 3½-ton six-wheelers.

The Burntisland Shipbuilding Co., Ltd., we understand, has received an order from the Joseph Constantine Steamship Line, Ltd., Middlesbrough, for a coasting vessel of 1,400 tons.

W. G. Bagnall, Ltd., of Stafford, have received orders for four 2-6-2- type locomotives and three 2-4-2 type locomotives for the Mysore State Railways. Further contracts have also been secured by this firm for six 4-6-0 type locomotives for the Gaekwar's Baroda State Railways.

Aldous and Campbell, Ltd., Lower Bland Street, London, have been awarded a contract by the London and North Eastern Railway Co. for five hydraulic lifts for Liverpool Street Station.

The General Vehicle Co., Ltd., of King's Cross Road, W.C. 1, have received an order from the Birmingham Corporation Salvage Department for a G.V. heavy low-loader (six-wheeler), fitted with G.V. hygienic body, and equipped with the new Dunlop low-loader pneumatic tyre 29 by 8 for 13-in. rim.

The Daimler Co., Ltd., of Coventry, have received orders from Wallasey Corporation for five double-deck chassis and from Doncaster Corporation for one similar chassis. These chassis are to embody the Daimler self-changing transmission and the six-cylinder poppet-valve type of engine.

The United Steel Companies, Ltd., and Messrs. Dorman Long and Co., Ltd., have been awarded a contract by the State Railways of Finland for the 1933 requirements of steel rails and sole-plates. The contract is estimated to involve 10,000 tons, valued at approximately £85,000.

Richard Thomas and Co., Ltd., have received an order for 1,000,000 boxes of tinplates from an American company operating in Canada.

The Great Western Railway Co. have placed orders for 100,000 steel sleepers, 46,500 tons of steel rails, fishplates, girders, etc., for their 1933 programme with several British firms. The total orders involve about 57,000 tons of steel.

Sir W. Arrol and Co., Ltd., have received an order for an electrically operated bridge from the Dublin Port and Docks Board. This bridge, which is estimated to cost £20,000, is to replace the swing bridge at Custom House Docks.

Messrs. Kryn and Lahy (1928), Ltd., Letchworth, have received a contract for steel castings and precision machine work from the Sullivan Machinery Co., an American company specialising in mining machinery. This contract is stated to amount to over £20,000.

Messrs. Lithgows, Ltd., Port Glasgow, have received an order for two cargo steamers from J. and C. Harrison, Ltd., Lonon. The new vessels will have a deadweight of 8,250 tons each, and the propelling machinery, on a new turbo-compressor system, will be supplied by David Rowan and Co., Ltd., of Glasgow.

Catalogues and Other Publications.

The Butler Machine Tool Co., Ltd., have sent us a copy of a new catalogue illustrating and describing the different types of draw-cut shapers they manufacture. The first part deals with a machine for shaping the flat pole seatings in motor yokes then follows a 48-in. portable draw-cut machine. The latest development of this type of machine by this firm is a portable machine, also with a 48-in. stroke, which has the body in two parts arranged so that the upper portion is self-contained and transportable. A special 60-in. draw-cut shaper supplied to a railway department of a Colonial Government is also shown. Copies are available on application to the Company at Victoria Ironworks, Halifax.

A new catalogue of books relating to mining, metallurgy, geology, and kindred subjects, including petroleum technology, has been issued by The Technical Bookshop, 724, Salisbury House, London Wall, London, E.C. 2. The books included are in all cases the latest editions at the time of going to press, and the catalogue should prove useful if only for reference purposes.

WELDING HIGH-SPEED STEEL.

The main purpose of most welding of high speed steel is to form tools at a cost considerably less than solid tools of high speed steel. The tipping of tools has been attempted with varying degrees of success for many years, but only during comparatively recent years has the method become a generally serviceable and commercially satisfactory operation. The subject is discussed by L. Sanderson in the November issue of "The Welder," in which he states there are three principal methods of welding high-speed steel:—The oxy-acetylene process, the butt-welding process, and the flash-welding process. The first is primarily a hand process, and its use is largely confined to the smaller shops, where an occasional job of tool-tipping or similar work has to be done. It is, on the whole, fairly reliable if carried out with care, but it is naturally costly. The second method is an electrical resistance process. It is quicker than the oxy-acetylene process and, therefore, more suitable to the repetitive work of modern large workshops. Its main difficulty is unreliability. The welder, however skilled, cannot be completely certain of making a satisfactory weld. The third and last method, of flash-welding, is rapidly supplanting all other methods where a large number of pieces have to be handled. It is absolutely trustworthy, quick, and a commercial proposition. It is, in essence, a development of the butt-welding process.

The various methods are discussed at length, but in general it may be said that the only reason why the welder of high-speed steel should have any ill-success is a lack of understanding of the class of steel he is attempting to weld, and because he has had insufficient practice. Many of the modern steels to which high-speed steel has to be welded, as, for example, the manganese-chrome alloy steel employed for the shanks of tools of heavy section, have a varied and intricate analysis, and demand care in their welding. The operator should not be discouraged by a few failures. He should study the materials with which he is dealing and accept any opportunity of practice. High-speed steel is a costly material, and it is easily burnt by injudicious use of the welding instrument. A little time and thought will repay the welder a thousandfold.

MARKET PRICES

ALUMINIUM.

98/99% Purity	£95 0 0

ANTIMONY.

English	£37 0 0 to £42 10 0
Chinese	26 10 0
Crude	19 10 0

BRASS.

Solid Drawn Tubes	lb.	9d.
Brazed Tubes	,,	11d.
Rods Drawn	,,	8¼d.
Wire	,,	7¾d.
*Extruded Brass Bars	,,	3¾d.

COPPER.

Standard Cash		£30 7 6
Electrolytic		35 10 0
Best Selected		33 0 0
Tough		31 15 0
Sheets		65 0 0
Wire Bars		36 0 0
Ingot Bars		36 0 0
Solid Drawn Tubes	lb.	10d.
Brazed Tubes	,,	10¼d.

FERRO ALLOYS.

‡Tungsten Metal Powder	lb.	0 1 10½
‡Ferro Tungsten	,,	0 1 7½
Ferro Chrome, 60-70% Chr. Basis 60% Chr. 2-ton lots or up.		
NOMINAL: 2-4% Carbon, scale 12/- per unit	ton	35 15 0
NOMINAL: 4-6% Carbon, scale 8/- per unit	,,	25 0 0
NOMINAL: 6-8% Carbon, scale 8/- per unit	,,	23 5 0
NOMINAL: 8-10% Carbon, scale 8/- per unit	,,	22 17 6
§Ferro Chrome, Specially Refined, broken in small pieces for Crucible Steel-work. Quantities of 1 ton or over. Basis 60% Ch. Guar. max. 2% Carbon, scale 11/6 per unit	,,	36 5 0
Guar. max. 1% Carbon, scale 14/ per unit	,,	40 15 0
§Guar. max. 0.7% Carbon, scale 15/- per unit	,,	44 10 0
‡Manganese Metal 96-98% Mn.	lb.	0 1 4
‡Metallic Chromium	,,	0 2 8
§Ferro-Vanadium 25-50%	,,	0 12 8
§Spiegel, 18-20%	ton	7 10 0
Ferro Silicon—		
Basis 10%, scale 3/- per unit	ton	5 17 6
20/30% basis 25%, scale 3/6 per unit	,,	8 10 0
45/50% basis 45%, scale 5/- per unit	,,	13 15 0
70/80% basis 75%, scale 7/- per unit	,,	19 0 0
90/95% basis 90%, scale 10/- per unit	,,	30 0 0
§Silico Manganese 65/75% Mn., basis 65% Mn.	,,	15 2 6
§Ferro-Carbon Titanium, 15/18% Ti	lb.	0 0 6
Ferro Phosphorus, 20-25%	ton	18 17 6

FUELS.

Foundry Coke—	
S. Wales	£1 0 0 to 1 2 6
Sheffield Export	— —
Durham	1 1 0 to 1 4 0
Furnace Coke—	
Sheffield	— —
S. Wales	0 16 0 to 0 16 6
Durham	0 12 0 to 0 12 6

GUN METAL.

*Admiralty Gunmetal Ingots (88 : 10 : 2)		£47 0 0
*Commercial Ingots		37 10 0
*Gunmetal Bars, Tank brand, 1 in. dia. and upwards	lb.	0 0 8
*Cored Bars	,,	0 0 10

LEAD.

Soft Foreign	£12 8 0
English	14 0 0

MANUFACTURED IRON.

Scotland—	
Crown Bars, Best	£10 5 0
N.E. Coast—	
Rivets	11 0 0
Best Bars	10 10 0
Common Bars	10 0 0
Lancashire—	
Crown Bars	9 15 0
Hoops	£10 10 0 to 12 0 0
Midlands—	
Crown Bars	£9 15 0 to 10 0 0
Marked Bars	12 0 0
Unmarked Bars	—
Nut and Bolt Bars	£8 7 6 to 8 12 6
Gas Strip	10 12 6
S. Yorks.—	
Best Bars	10 10 0
Hoops..Hoops	£10 10 0 to 12 0 0

PHOSPHOR BRONZE.

*Bars, "Tank" brand, 1 in. dia. and upwards—Solid	lb.	8d.
*Cored Bars	,,	10d.
†Strip	,,	10½d.
†Sheet to 10 W.G.	,,	10¾d.
†Wire	,,	11⅝d.
†Rods	,,	11d.
†Tubes	,,	1/4
†Castings	,,	1/1¼

†10% Phos. Cop. £30 above B.S.
†15% Phos. Cop. £35 above B.S.
†Phos. Tin (5%) £30 above English Ingots.

PIG IRON.

Scotland—	
Hematite M/Nos.	£3 7 6
Foundry No. 1	3 10 0
,, No. 3	3 7 6
N.E. Coast—	
Hematite No. 1	3 0 0
Foundry No. 1	3 1 0
,, No. 3	2 18 6
,, No. 4	2 17 6
Cleveland—	
Foundry No. 3	2 18 6
,, No. 4	2 17 6
Silicon Iron	3 1 0
Forge No. 4	2 17 0
Midlands—	
N. Staffs Forge No. 4	3 1 0
,, Foundry No. 3	3 6 0
Northants—	
Forge No. 4	2 17 6
Foundry No. 3	3 2 6
Derbyshire Forge	3 1 0
,, Foundry No. 3	3 6 0
West Coast Hematite	3 6 0
East ,, ,, No. 1	3 0 0

SWEDISH CHARCOAL IRON AND STEEL.

Kr. per English ton @ 18/6 to £1 approximately.

Pig Iron Kr. 92	—
Billets ..Kr. 280-290	£15 10 0-£16 0 0
Wire Rods Kr. 265-320	£14 12 6-£17 12 6
Rolled Bars (dead soft) Kr. 185-210	£10 4 0-£11 11 0
Rolled Charcoal Iron Bars Kr. 290	£16 0 0

All per English ton, f.o.b. Gothenburg.

SCRAP METAL.

Copper Clean	£24 0 0
,, Braziery	21 0 0
,, Wire	—
Brass	16 0 0
Gun Metal	20 0 0
Zinc	8 10 0
Aluminium Cuttings	72 0 0
Lead	10 10 0
Heavy Steel—	
S. Wales	2 0 0
Scotland	1 15 0
Cleveland	1 17 6
Cast Iron—	
Midlands	1 16 0
S. Wales	2 2 0
Cleveland	1 17 6
Steel Turnings—	
Cleveland	1 8 6
Midlands	1 0 6
Cast Iron Borings—	
Cleveland	1 3 6
Scotland	1 10 0

SPELTER.

G.O.B. Official	—
Hard	£12 15 0
English	16 2 6
India	14 5 0
Re-melted	14 10 0

STEEL.

Ship, Bridge, and Tank Plates—	
Scotland	£8 15 0
North-East Coast	8 15 0
Midlands	8 17 6
Boiler Plates (Land), Scotland	9 0 0
,, ,, (Marine) ,,	—
,, ,, (Land), N.E. Coast	10 0 0
,, ,, (Marine) ,,	10 10 0
Angles, Scotland	8 7 6
,, North-East Coast	8 7 6
,, Midlands	8 7 6
Joists	8 15 0
Heavy Rails	8 10 0
Fishplates	12 0 0
Light Rails	£8 10 0 to 8 15 0
Sheffield—	
Siemens Acid Billets	9 2 6
Hard Basic	£8 2 6 and 8 12 6
Medium Basic	£6 12 6 and 7 2 6
Soft Basic	6 0 0
Hoops	£9 10 0 to 9 15 0
Manchester—	
Hoops	£9 0 0 to 10 0 0
Scotland, Sheets 24 B.G.	10 5 0

HIGH SPEED TOOL STEEL.

Finished Bars 14% Tungsten	lb.	2/-
Finished Bars 18% Tungsten	,,	2/9
Extras		
Round and Squares, ½ in. to ¾ in.	,,	3d.
Under ¼ in. to 3/16 in.	,,	1/-
Round and Squares 3 in.	,,	4d.
Flats under 1 in. × ⅜ in.	,,	3d.
,, ,, ¼ in. × ½ in.	,,	1/-

TIN.

Standard Cash	£152 0 0
English	153 0 0
Australian	155 17 0
Eastern	157 2 6
Tin Plates I.C. 20 × 14 box	0 16 0
Block Tin (Cash)	152 5 0

ZINC.

English Sheets	£24 10 0
Rods	27 0 0
Battery Plates	—

* McKechnie Brothers, Ltd., quoted Dec. 12. † C. Clifford & Son, Ltd., quoted Dec. 9. ‡ Murex Limited, quoted Dec. 9.

Subject to Market fluctuations. Buyers are advised to send inquiries for current prices.

§ Prices quoted Dec. 9, ex warehouse.